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Jay, Gregory T.

Monterey, California. Naval Postgraduate School

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN EXPERIMENT IN VOICE DATA ENTRY FOR
IMAGERY INTERPRETATION REPORTING

by

Gregory T. Jay

March 1981

Thesis Advisor G. K. Poock

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Buffered voice and unbuffered voice modes of the T600 were evaluated with typing: buffered voice was 58% faster, and unbuffered voice 41% faster than typing. Voice was also found to be as accurate as typing for writing short order of battle reports. Finally, subjects preferred voice for several criteria evaluated before and after the experiment.

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An Experiment in Voice Data Entry for Imagery Interpretation Reporting

by

Gregory T. Jay
Captain, United States Air Force
B.S. Ed., Miami University of Ohio, 1970
M.S. Ed., Miami University of Ohio, 1971

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY - C3

from the

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March 1981

ABSTRACT

This thesis investigated the feasibility of voice data entry for imagery intelligence order of battle reporting. Time, accuracy, and efficiency were measured for 20 subjects in an experiment physically simulating the use of a light table, optics, and an interactive computer system for reporting. A Threshold Technology Inc. T600 voice recognition system was used for a large, unstructured vocabulary (255 words) of unclassified Soviet/Warsaw Pact equipment names, alphanumerics, and editing commands. The T600 reccgniton accuracy for this experiment was 97.0% without rejects, and 95.5% with rejects.

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> I give thanks to the Lord, for He is good; for His lovingkindness is everlasting [Psalm 118:29].

I. BACKGROUND LEADING TO EXPERIMENTATION

A. INTRODUCTION

This thesis investigates the potential application of automatic speech recognition (ASR) technology to military imagery interpretation reporting. It stems from the author's background in three areas: imagery interpretation, Intelligence Data Handling Systems (IDHS), and recent exposure to the benefits of voice data entry as an alternative modality for interacting with machines, especially computers.

The need for the thesis arises from two areas: the need to evaluate and advance current ASR technology without major redesign of systems; and the need for faster, reliable reporting systems for the intelligence community. Dr. Wayne Lea and Dr. Gary Poock called for the evaluation of state-of-the-art ASR equipment, specifically, to evaluate input modalities, e.g. voice versus typing [Refs. 1 and 2]. The intelligence community is continually seeking ways to improve performance of imagery sensors and exploitation and reporting systems, and is very interested in ways of reducing costs while improving the quality of intelligence to tactical and strategic users.

The Soviet Union and the Warsaw Pact countries are expected to employ mass, mobility, and surprise tactics in

any future European attack scenario on our North Atlantic Treaty Organization (NATO) Allies. The speed and range of modern weaponry leave little or no room for mistakes in responding to crisis situations. Decision-making in minutes or even seconds is a requirement today, and is likely to be more critical in the future with the increased use of microelectronic components for sensor and weapons control, and faster, more redundant, survivable, and interoperable communications facilities. National Command Authorities, U.S. Strategic and Tactical Forces, and NATO Theater Forces must have accurate, timely, and complete indications and warning (I&W) intelligence of the enemy's real intentions and capabilities. Once hostilities begin, with today's warfighting technology, military commanders will require near-real-time (NRT) combat information to enable them to provide effective command and control of their forces to counter the enemy.

Globally, intelligence must be available for national security decisions regarding appropriate responses to international terrorism and the unwarranted intervention of foreign powers into the affairs of other nations. Additionally, intelligence is required for long-range planning estimates to support the acquisition of the best possible mix of forces to meet mission requirements in support of basic U.S. policy and objectives. Finally, intelligence must

continually support Strategic Nuclear Command and Control forces which must always be at a sufficient state of readiness to provide nuclear deterrence.

The following basic command and control model in Figure 1 was adapted from the work of Dr. Joel Lawson, Technical Director, Naval Electronics Systems Command [Ref. 3]. It is shown here to illustrate the importance of the intelligence process in providing support to command and control of forces in war and peace. Note that it does little good to provide better sensors without also improving the ability to compare the information derived with objectives and historical information in conjunction with intelligence analysis, inherent in the "compare" process. In the reconnaissance area, imagery exploitation and reporting would fall under the "compare" function of the system, and as such can be a major information "bottleneck" if not capable of effectively processing the sensor output to meet the information needs of the decision-maker.

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Figure 1. Basic Command and Control Model

Regarding the central importance of the command and control process, Dr. Lawson states,

> ...the central problem of command control is producing an up-to-date geographic display of the location of "things." Besides purely the location of things he [the commander] needs to know what [the] things are, what is their identity, or who do they belong to and what is their status.

Imagery is a key source of such information, and is thus a major contributor to the command and control process.

Automated imagery interpretation reporting systems have been employed for strategic and theater support for over 10 years, and new systems which include exploitation aids are being deployed to tactical units now. They have

significantly reduced the time to explcit and report all types of imagery intelligence. However, the man-machine interface research and development of these systems must continue to meet future challenges facing the intelligence community. Significant volumes of imagery intelligence will be available from NRT digital imagery sensors in the future, and the best possible man-machine interface must be sought to effectively explcit I&W, order of battle, targeting, and damage assessment intelligence available from imagery.

Reporting speed and accuracy, manpower reductions,and increased throughput are worthy design goals for new or improved imagery exploitation and reporting systems. Voice data entry is one newly evolving technology that offers significant potential toward these goals. Dr. Wayne Lea, in the introduction to his book Trends in Speech Recognition, 1980, said:

> Speech input seems to offer a truly natural mode of human-machine communication that, if attainable in a cost-effective way, would be unsurpassed in making computers and other mechanical devices truly cooperative servants of mankind, rather than increasing the demands on the human to adapt to the machine [Ref. 4].

The next section briefly overviews the functions of imagery reporting systems, provides some examples of systems for today and tomorrow, and mentions some specific requirements which lead to the desirability of voice data entry for imagery intelligence reporting.

B. IMAGERY INTERPRETATION REPORTING SYSTEMS

1. Functions

A military imagery interpretation system basically functions to provide support for first, second, and third phase exploitation of multi-sensor imagery in response to tasking from parent or outside user organizations. These phases represent three levels of depth of imagery analysis in accordance with Defense Intelligence Agency (DIA) standard reporting procedures, data elements, and requirements.

First and second phase reports represent the bulk of the work, and are called Initial/Supplementary Photo Interpretation Reports (IPIRs/SUPIRs). The IPIR may be thought of as a quick, concise response to time-sensitive requirements. It is often followed by the SUPIR, which represents a more detailed and thorough exploitation effort. Third phase reporting is the most detailed, and includes special analyses and reporting of selected installations of specific interest to users of imagery products.

Such reporting standards and systems grew out of requirements forced by large increases in the volume of available imagery during the sixties. During the sixties, the volume of imagery exceeded the exploitation capabilities by a factor of five to ten [Ref. 5]. This drove the development of a variety of imagery exploitation and reporting systems which came into operation in the

seventies, and forced standards for reporting on the imagery intelligence community as a whole. These developments permitted the sharing of imagery intelligence via magnetic tape files and bulk data transfers over communications circuits. It also facilitated the integration of imagery intelligence into more general data bases, and enhanced the "corporate memory" of intelligence units, since interpreters often kept installation data in small personal files, not easily accessed by others. With better data bases, explcitation was enhanced and duplication of effort was reduced.

Today, imagery exploitation systems are located worldwide in support of U.S. military commanders. The focus now is on providing more integrated data bases, which are optimally dynamic, complete, and timely. Multi-source imagery reports may be telecommunicated to and from many of the sites, and distributed to users with a valid requirement. Integrated data bases will afford producers and users with more responsive, coordinated information in time of need.

Imagery systems range from national level to tactical reconnaissance squadron level systems. They have become increasingly capable of supporting many tasks associated with exploitation and reporting: responding to tasking transmitted over telecommunications networks; managing interpretation hardware, software, and data base

resources; exploiting the imagery to include making measurements on the imagery, correlating imagery with maps, composing reports, editing them, and other support functions; disseminating reports; and automatic screening and updating of local imagery and multi-source data bases.

2. <u>Examples of Imagery Interpretation Reporting Systems</u>

The DIA uses the Automated Imagery Related Exploitation System (AIRES), modeled after the PACER system used by the Strategic Air Command's 544th Aerospace Reconnaissance Technical Wing. PACER means Program Assisted Console Evaluation and Review, and consists of a dual Honeywell 6080 based computer system and UNIVAC 1652 consoles supporting the interpretation process. Both systems support a wide variety of analyst functions.

A system developed and installed in the late seventies for theater and tactical user support is the Computer Assisted Tactical Information System (CATIS). This system is used by fixed-site, imagery exploitation units in the Pacific Air Forces (PACAF), the Tactical Air Command (TAC), the Fleet Intelligence Center for Europe and the Atlantic (FICEURLANT), the United States Air Forces in Europe (USAFE), and the training site in Air Training Command (ATC). The imagery exploitation support provided by CATIS may be viewed in Figure 2.

To provide highly mobile support, the Tactical Information Processing and Interpretation, Imagery

Interpretation System (TIPI IIS) was developed, and is being deployed to Air Force, Marine, and Army tactical reconnaissance support units worldwide. The photo interpretation console of the TIPI IIS may be viewed in Figure 3, displaying a great deal of modular, ruggedized support equipment for imagery interpretation reporting and communications. This system provides mobile automation at the squadron level, not previously available. For example, an interpreter can use a cursor in the light table to make rapid, accurate measurements of objects such as bridges, runways, and storage tanks and store the answer on an electronic scratch pad for later insertion into a report. Reports are filled in quickly, using a fill-in-the-blank online report composer. They may then be edited by a supervisor, and distributed over secure communications links.

To perform side-looking airborne radar (SLAR) exploitation and reporting the TIPI Manual Radar Reconnaissance Exploitation System (MARRES) was developed, but with a different console (Figure 4). This system provides special readout of radar imagery that may be used in good or bad weather, and is useful for discovering enemy force movements in inclement weather, such as that found in Europe. Unique man-machine systems have been

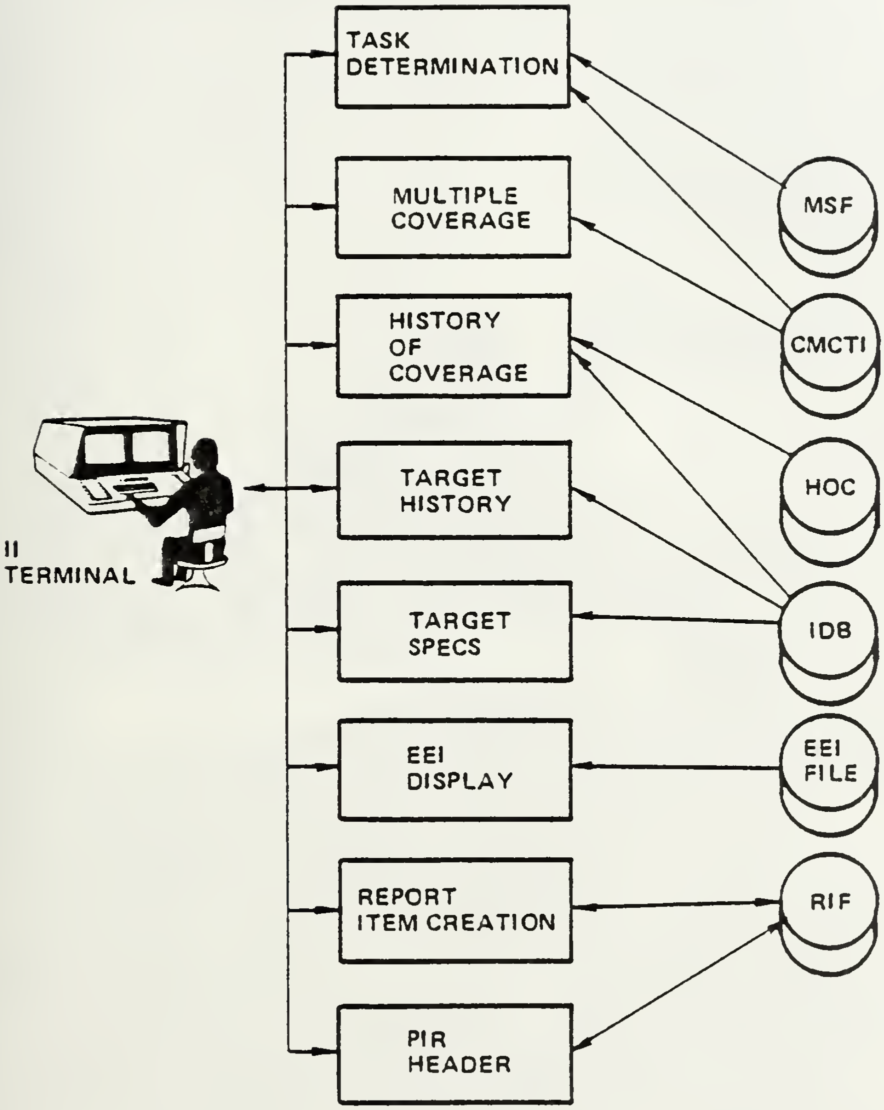

Figure 2. CATIS Imagery Exploitation Support

(Adapted from CATIS User's Manual, 1979)

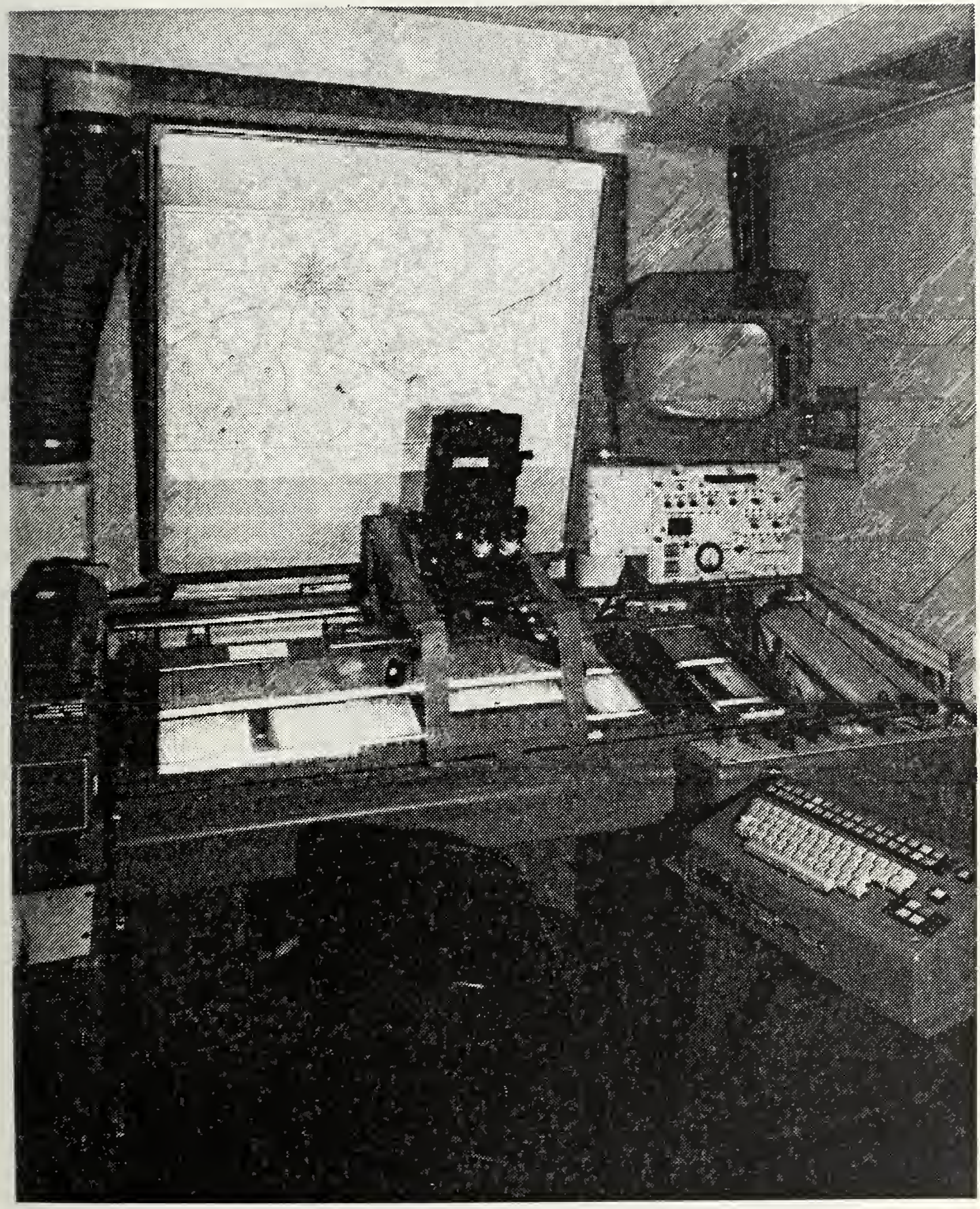

Figure 3. TIPI Imagery Interpretation System (IIS)

(Courtesy of Texas Instruments, Inc.)

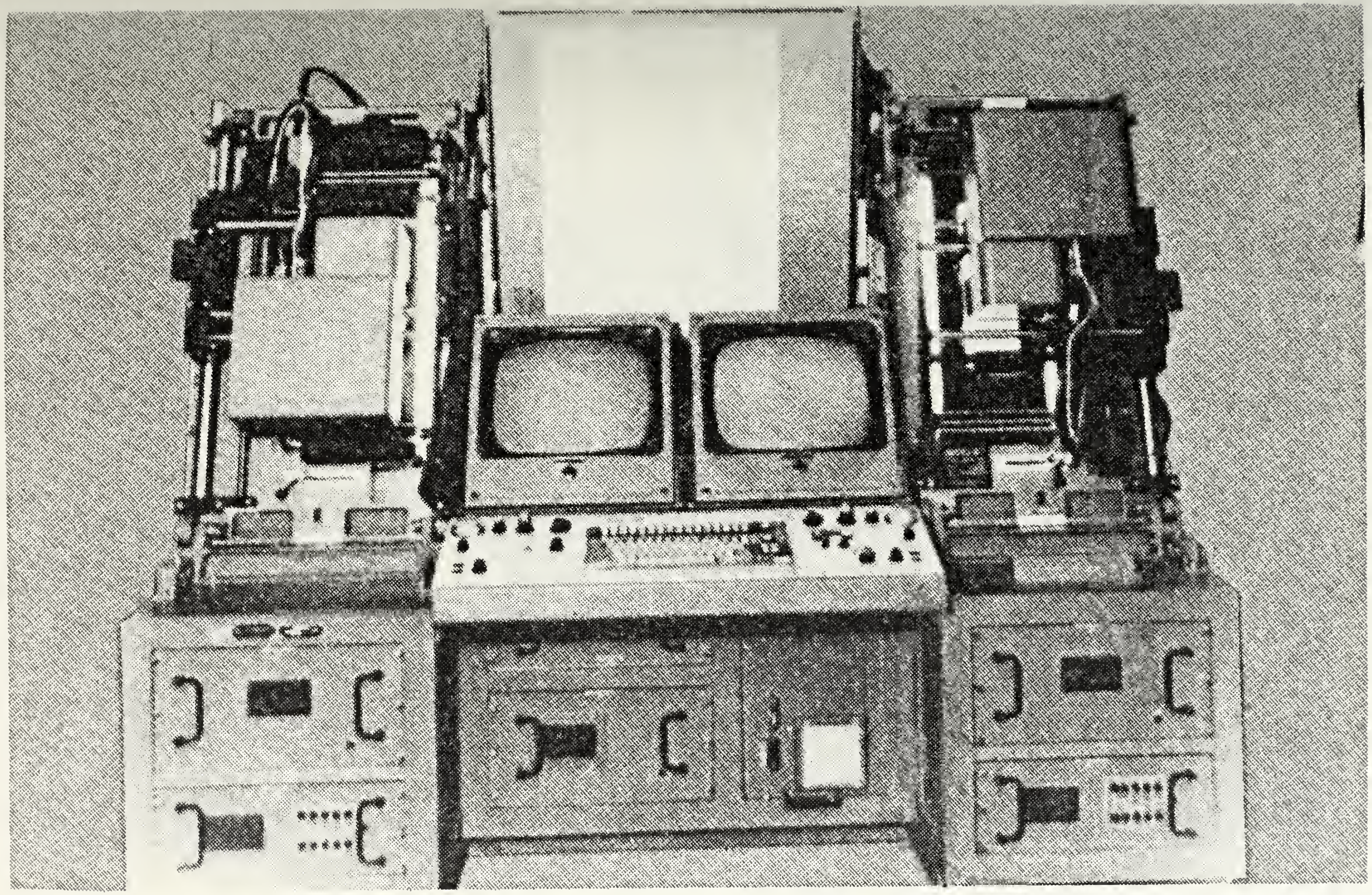

Figure 4. TIPI Manual Radar Reconnaissance Exploitation System (MARRES) (Courtesy of Texas Instruments Inc.)

provided to assist in providing detection of changes in the landscape or order of battle.

New NRT digital imagery reconnaissance sensors, such as foward-looking infrared imagery (FLIR), Synthetic Aperature Radar (SAR), or other types of imagery which can be supported by sensors on tactical aircraft will result in increased NRT imagery. Exploitation systems to support the sensors must be developed to provide the additional support required. The Air Force has initiated advanced developmental models to prepare for such a requirement.

One system is the Reconnaissance Reporting Facility developed to support the Quick Strike Reconnaissance concept whereby the reporting facility would receive NRT hardcopy and softcopy (digital) imagery from reconnaissance aircraft over the forward edge of the battle area. When advancing enemy forces posed themselves as targets of opportunity, imagery reports would notify the strike center to order nearby airborne loitering aircraft to destroy the target. Figure 5, top and bottom, gives views of the shelter developed to test the NRT reporting concept.

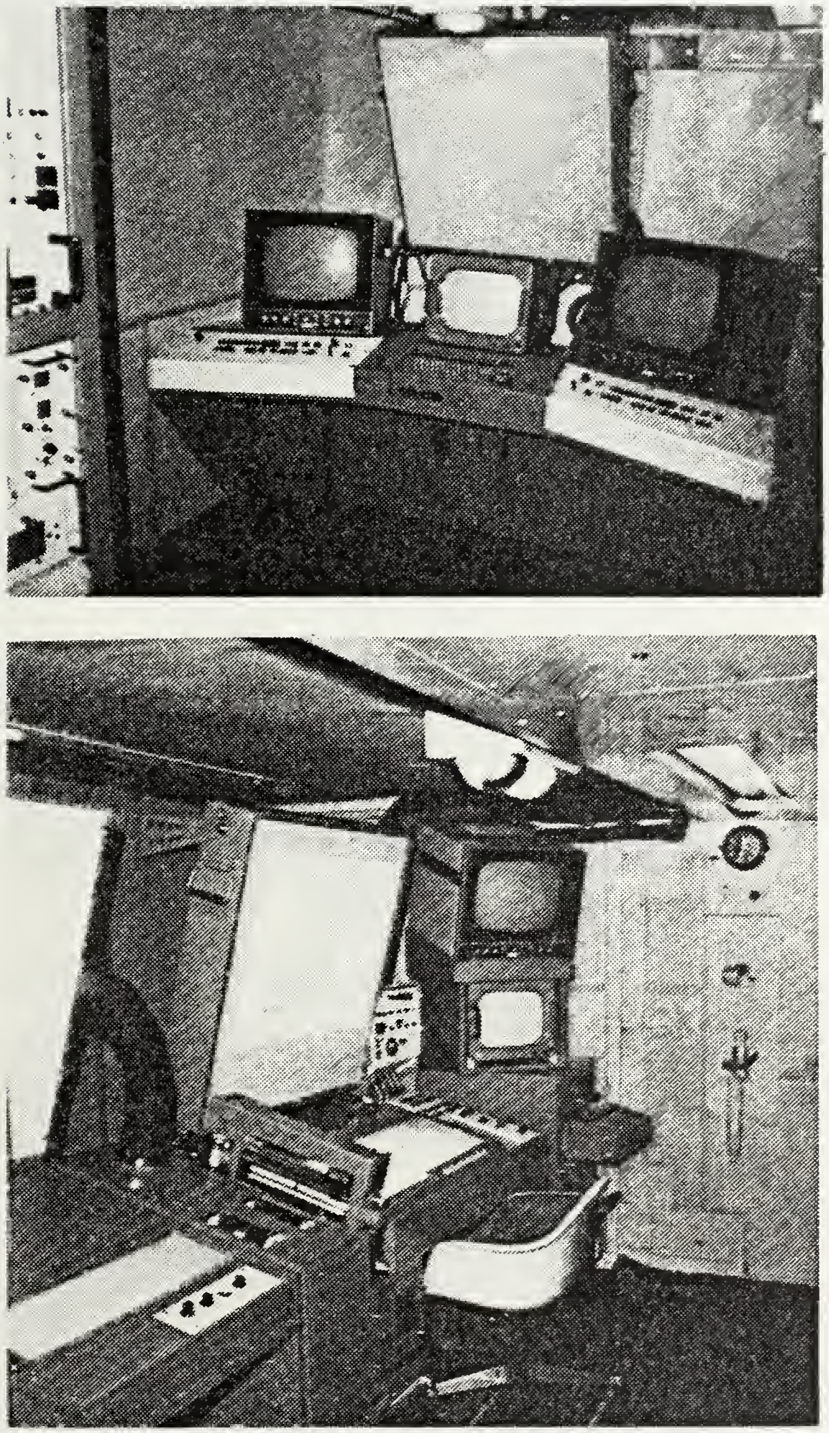

Figure 5. QSR Reconnaissance Reporting Facility (RRF)

(Courtesy of Texas Instruments, Inc.)

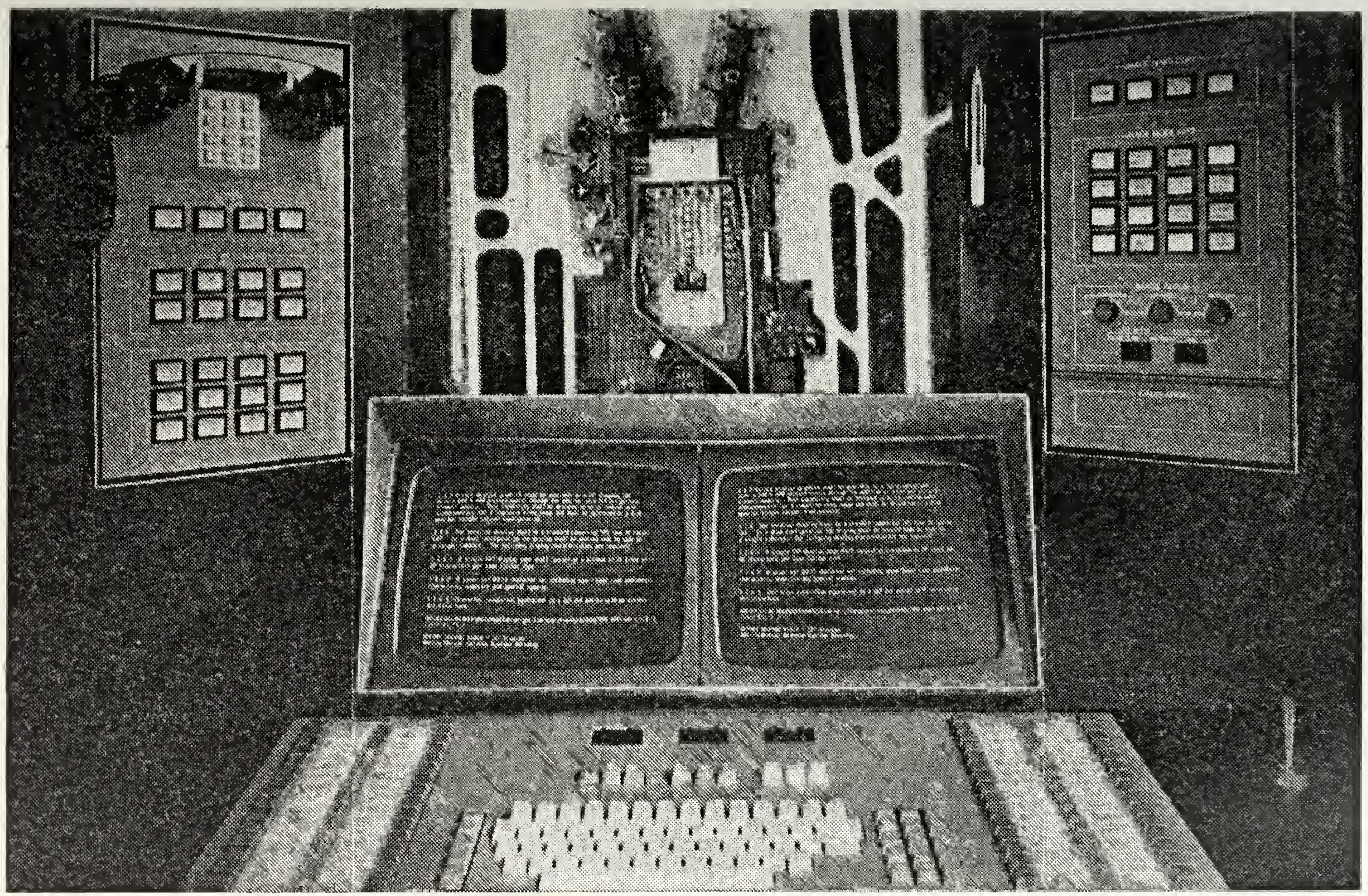

Figure 6. Compass Preview
Digital Exploitation System
(Courtesy of Northrop Corporation)

The RRF contains computers, communications, and both hardcopy and softcopy imagery exploitation and reporting stations. Used during exploitation of a target-rich wartime environment, this facility would pose a challenging work environment for the best of interpreters and supervisors. Efforts to optimize the man-computer interface could only result in improved responsiveness and greater system capability.

Another system, for strategic use, is the Compass Preview digital imagery exploitation system shown in Figure 6. For the first time, interpreters will be able to view stereo images without the aid of a light table, hardcopy imagery, or a stereoscope. The interpreter can use computer support to enhance the image to improve its interpretability in terms of scale, contrast, sharpness, and other image qualities. Simultaneously, historical data base information and reporting formats are available for reporting what is seen on the image and correlated with other data. Measurements may also be made using a joystick and cursor.

The imagery systems discussed represent a large leap forward in imagery intelligence since the late sixties. The results from current systems such as PACER and CATIS are encouraging with 3:1 and 12:1 increases in output as compared to their predecessors, less duplication of effort, increased validity of reporting, and most importantly, better responsiveness to specific user questions.

Imagery reporting systems are quite sophisticated, having incorporated not only state-of-the-art exploitation techniques, but others as well from computer, communications, and other intelligence disciplines. Significant skill and training are required to operate them effectively. Interpreters are not trained typists, and thus their speed may slow the reporting process. Additionally, they may have an inherent fear of working with computers. Continuing attention must be given to improving the man-machine interface to optimize the system product: complete, accurate, and timely imagery intelligence. Though not a panacea, voice data entry may be part of the solution for improving the imagery interpretation systems, by improving man's interface with the machine, and making optimal use of man's skills as an image analyst.

3. Requirement for Voice Data Entry

During the author's recent assignment at the Armed Forces Air Intelligence Training Center, he was responsible for managing the initial development of the TIPI IIS Operator and Supervisor Courses. As he observed interpreters training on the prototype, it was often apparent that they were deficient in typing skills. It was painfully obvious that the multi-million dollar IIS would not produce reports any faster than the few words-per-minute of the "hunt and peck" typist. Certainly, with practice

individuals may improve their typing speed and accuracy as they adapt to a system, but as we have seen, the trend is toward faster reporting, and somehow the problem of data entry must be attacked or critical resources will be wasted on systems limited by the the man-in-the-loop.

One simple and effective way may be to conduct typing classes to improve interaction with the computer. In fact, online routines for teaching better typing could be developed to improve the interpreters' skills between missions. Another way may be to use voice data entry, which offers a great potential beyond even the fastest typists for data entry, should be easier and faster to train, and could be used in conjunction with typing, function keys, or a variety of other input modalities.

C. AUTOMATIC SPEECH RECOGNITION

1. Overview

Automatic Speech Recognition (ASR) is no longer a dream of the future, but a technology being applied around the world by people who use machines, allowing effective machine control and data entry into computers. ASR is not without problems or limitations however, and must be carefully examined before trying to apply it. Human factors must be studied and tailored to the application to allow ASR to have the appropriate impact it affords. Failure to attend to operator considerations such as microphone

mounting, recognition accuracy, error correction, response time and delay, feedback and prompting, stability of reference data, and training procedures can have catastrophic effects on system performance for both the voice system and the system it aids [Ref. 7].

The ultimate goal for speech recognition science is to develop "speech understanding systems" which give the appropriate response to the user's request, and do not just recognize the elements of speech or words and phrases [Ref. 8]. Admittedly, the technology is not that far along, but many applications do not need or cannot afford the ideal speech system. The question that must be asked now is "what applications can be accomplished in a more cost-effective manner with voice recognition systems that are available now or will be available within the next few years?"

Speech scientists have been working on ASR for about 28 years. Commercially available speech recognizers became available in 1972 with Scope Electronics, Inc. and Threshold Technology Inc. delivering quality systems which achieved significant results under a variety of conditions. In general, recognition accuracy scores from 99.0% to 99.9% accuracy have been achieved in laboratory conditions of no noise, adequate talker training, and consistent talking habits. Field testing, however has usually achieved results in the neighborhood of 97% recognition accuracy, generally

as a result of high background noises or speaking to the system in a manner different than the way the system was trained initially.

All ASR systems fall into either of two categories: continuous (connected) or isolated (discrete) speech systems [Ref. 9]. Continuous speech systems work on the extraction of information from strings of words that may be run together in natural speech in the form of strings of digits, phrases, or sentences. Isolated-word recognizers require that a short minimum-duration pause be inserted between digits, words or phrases which must be spoken within a given period of time, e.g. two seconds.

These isolated-word recognizers are more prevalent today as they are less expensive, more accurate, work in real-time, and are more readily available. Continuous speech systems, however, may be available within the next few years offering 250 word vocabularies and recognition in real-time at a reasonable price. Continuous speech systems, in the upper end of the cost spectrum, are approximately $100,000. High quality isolated-word speech recognizers normally cost in the tens of thousands of dollars today; however, a few companies are also introducing systems on the market for a few thousand dollars that can recognize vocabularies of about 250 words with recognition accuracies of 97% or better, according to Dr.Poock, who intends to compare such systems at NPS for

command and control applications. At the bottom end of the cost spectrum, hobby systems are currently available for a few hundred dollars.

Dr. Lea, well recognized for his work in speech science at the University of Southern California and the Speech Communication Research Laboratory said this about the future of speech recognition technology:

> The next ten years or more would seem to offer a growing spectrum of available devices, ranging from very low cost isolated word recognizers, through digit string recognizers, recognizers of strictly formatted word sequences, task-restricted speech understanding systems, and more powerful research systems for continuous speech recognition. All such systems will take advantage of low-cost miniaturization hardware that puts speech recognizers within the reach of most potential users... User acceptance of voice input will approach the "matter-of-fact" attitudes now prevalent with limited keyboard entry, even though full versatility and "habitability" of input languages will not have been attained to any major degree... Despite all these advances, we will be far from the science fiction image of fully versatile voice interaction with machines, and I doubt that unrestricted "phonetic typewriters" are a part of the next decade or more of practical work on speech recognition [Ref 10].

2. Value of Speech Recognition Systems

Speech input to machines can be of significant value, but under what conditions or situations? This section discusses some of the advantages and disadvantages of speech input described by Dr. Lea.

Speech systems offer the potential to capitalize on the best of man's communicative abilities, give him compatibility with unusual circumstances, and help him gain additional mobility and freedom in some situations [Ref. 11]. Speech is said to be the human's most natural communication modality. It is familiar, convenient, and can be used spontaneously because the individual uses it often in all types of situations. Though performance with voice may degrade under situations of stress, it may not degrade as much as a less learned, less frequently used skill. Since voice is familiar to the user, it is less difficult to train him to use the system. Additionally, voice is the human's highest-capacity output channel, and permits simultaneous communications with humans and machines. For example, a speaker in a large auditorium or a command center can display the next visual on a large screen display by saying some key phrase or word which has meaning to both listener and display system. To illustrate, when Dr. Poock recently briefed a group of senior naval officers in the Pacific, he used such key phrases as "Good Morning Admiral..." to begin his briefing, and "here you see the (pause) SHIPS ..." to convey briefing information and tell the command and control graphics display system to present the next graphic in his presentation on the subject of Voice Input for Command and Control. This is just one

illustration of the creative ways man can use voice input to his advantage.

Navy feasibility studies sponsored by Naval Electronics Systems Command, and conducted by Dr. Poock, examined the potential for voice data entry for command, control, communications, and intelligence. Two voice recognition systems were installed in late 1980 at Fleet Headquarters, Commander-in-Chief of the Pacific (CINCPAC) in Hawaii to examine the benefits and limitations of voice input for operation of the Worldwide Military Command and Control Time-Sharing System (WWMCCS TSS) and the nearby Ocean Surveillance Intelligence System (OSIS). One advantage of many of the new voice terminals is that they are stand-alone, intelligent terminals with standard communications interfaces and character sets that can be interfaced rapidly with computers possessing those same generic interfaces. Voice units may be moved around easily and installed as simply as most other modern RS-232 plug-compatible terminals. Voice may also be used remotely as much as 2000 feet from the main computer, free from any panel space, displays, or complex apparatus.

The advantages of voice input for complementing the communicative abilities of man are offset somewhat today since a user cannot speak totally naturally, but must insert pauses in between utterances, and must use utterances within the constraints of the voice

system's stored vocabulary. This requires the user to be very familiar with the vocabulary in use, not unlike knowing the letters of the alphabet.

Speech input for machines is also of value in helping man cope with unusual circumstances. For example, it can be used in complete darkness, around obstacles, by the blind and other handicapped individuals, is unaffected by weightlessness, and only slightly affected by high acceleration and mechanical constraints. On the negative side, it is often sensitive to dialect, and also susceptible to background noise and distortions. Additionally, a microphone must either be worn or held in close proximity to the speaker. And finally, a display or synthesized voice feedback may be necessary for tasks requiring data entry validation.

The mobility possible with voice input is one of its greatest attributes. It enables operation of devices from a distance and from various orientations, permits simultaneous use of hands and eyes for other tasks, and can even permit the telephone to be used as a computer terminal. Some degree of privacy is lost, although users often operate in the laboratory at NPS inconspicuously running graphics displays and other command and control applications without bothering other nearby terminal operators.

The key questions to keep in mind when considering the value of speech input are: "Is there an application that

could be done more cost-effectively using voice as a single or additional input modality?...and, " Is the current technology adequate to provide the quality, naturalness, and speed that the application of interest requires?" A brief look at the military's efforts in voice technology may help the reader to further assess the value of speech technology for his own application.

3. Military Research and Applications

Research supported by the Advanced Research Projects Agency (DARPA), which funds leading-edge technology, was a prime ingredient contributing to the development of voice technology. However, a large number of military projects, such as the ARPA Speech Understanding Research, met with limited success as a great deal of work in acoustic-phonetics, speech perception, linguistics, and psychoacoustic equipment is still necessary to provide the foundation for ASR to approach human performance [Ref 12].

Most of the research in the military has turned to taking off-the-shelf isolated-word recognizers and adapting them to particular applications. Recognition studies in the military have been done for applications in aircraft cockpits, tactical field data entry, military training systems, cartography, command and control of networks, wargames and graphics, keyword spotting of communications channels, emergency action message composition, and imagery interpretation tasks such as mensuration and reporting. The

applications most closely related to this thesis are the cartography, command and control of displays, and imagery interpretation reporting.

A significant amount of research was performed for the Defense Mapping Agency(DMA) by contractors under the program management of the Air Force's Rome Air Development Center(RADC). The Defense Mapping Agency Aerospace Center (DMAAC) and the Defense Mapping Agency Aerospace and Hydrographic Center (DMAHC) produce large volumes of cartographic products for the military and other users. Research has been performed for such applications as voice data entry for the processing of Digital Landmass System (DLMS) data, preparation of Flight Information Publications (FLIPS) data, and ocean-depth measurements for digitized cartographic applications. In these applications analysts were performing tasks in an "eyes busy, hands busy environment," sometimes with stereo optics and or other special devices. Voice was shown experimentally to be faster, easier, and a less fatiguing mode of data entry than the more conventional modes used [Refs. 13, 14, and 15]. User acceptance and system support can be significant problems, as explained by DMAAC officials to the author during a recent visit to their facilities.

The NPS is currently performing voice data entry research in the area of command and control applications. In a study by Poock, twenty-four command and control

students operated the ARPA network or ARPANET, a distributed network of computers in the U.S. and Europe, using voice and typing as a comparison between the two modes [Ref. 16]. Voice was significantly faster and more accurate for entering commands into the system. Additionally, students were given an secondary transcription task to perform while operating the ARPANET. The voice mode permitted substantially more data to be transcribed than the typing mode. On the other hand, McSorley recently demonstrated that voice was no faster than typing for entering commands into a wargame. This was due in part to the poor editing features of the game, but demonstrates that voice is not for everything [Ref. 17].

In the area of imagery interpretation, interest in voice data entry is growing. RADC recently completed a study which evaluated a voice recognition system known as "Talk and Type," built by Threshold Technology Inc., to study the application of voice data entry to the problem of imagery interpretation and intelligence report generation [Ref. 18]. The innovation by Threshold required the user to type the first letter of the word to be recognized. In this manner the voice system restricted the size of the vocabulary to be searched, thereby increasing recognition accuracy. Four varied tests were performed looking at small and large vocabularies, and especially tasks where the subject was describing scenes the way an interpreter might

describe a bridge or a runway. The results showed the Talk and Type system to be superior over typing for unskilled typists.

Soon the new ground station for the Tactical Reconnaissance-1 (TR-1) aircraft is expected to be built to provide exploitation and reporting support for the sensors aboard the U-2 derivative aircraft which is expected to provide NRT reconnaissance support to theater forces. According to the program manager, voice data entry is a serious consideration for inclusion into the program.

D. SUMMARY

The purpose of this thesis is to investigate the potential application of ASR technology to military imagery interpretation. The research responds to the need for rapid, concise, valid information for command and control of forces in peace and war. The functions of the imagery reporting systems include support for a variety of tasks, especially composing reports. The specific focus of the thesis is to examine the feasibility of writing order of battle reports using a large voice vocabulary of 255 words of USSR/Warsaw Pact military equipment names, editing commands, and alphanumerics.

Several examples of modern operational and developmental imagery exploitation and reporting systems were briefly discussed which represent potential systems

for application of voice technology. Incorporation of ASR technology could result in improved capabilities in terms of speed, accuracy, and completeness of imagery reporting. ASR technology makes optimal use of the fact that speech is man's most natural input modality, while the limited speeds of interpreters typing may not optimize advanced reporting system capabilities.

The advantages and disadvantages of speech were presented. Some of the value of speech input awaits technological breakthroughs and may not be realized in this decade. The military is not waiting however, and seems unwilling to pay for all the basic research to push continuous speech systems. Instead, the military is hard at work with applications efforts with limited-vocabulary, isolated-word, speaker-dependent voice recognition systems, proven to be reliable and accurate for the right applications, while monitoring and sometimes supporting work by private contractors, hopefully leading to practical continuous speech systems.

The objective of this thesis is to support military applications research efforts aimed at comparing input modalities, and afford the intelligence community an independent data point regarding the overall evaluation of ASR. This research began independent of the related RADC research, and thus serves to underscore the appropriateness of voice data entry support to the task.

II. DESCRIPTION OF THE EXPERIMENT

A. OBJECTIVES AND CONSTRAINTS

The objective of this experiment was to determine if state-of-the-art voice data entry equipment was feasible for reporting imagery-derived order of battle (OB) intelligence using an interactive computer system. The experiment was designed to determine if there was any significant difference in speed, accuracy, efficiency, and subject attitudes regarding manual keyboard and voice data entry for this task. A large unclassified vocabulary of 255 words containing alphanumerics, commands, and representative USSR/Warsaw Pact equipment names was selected for the reporting scenario (see Appendix A). Based on recent research, voice data entry was expected to be faster, more accurate, and preferred by subjects over manual keyboard data entry [Ref. 18].

Accomplishment of this objective was constrained within the research facilities of the Naval Postgraduate School (NPS). In the interest of time and money, the process of reporting was simulated to the maximum degree possible within the constraints of available subjects and laboratory facilities. This simulation, though not ideal, afforded an effective, economical tool to accomplish this objective.

B. SUBJECTS

Twenty subjects participated on a volunteer basis. The group was composed of 18 military officers, and two civilians. The military officers, representing the Army, Navy, Air Force, and Marines included 17 males and 1 female; their grades ranged from Lieutenant to Commander and from Captain to Lieutenant Colonel. The civilians included an employee of the National Security Agency and a professor from the NPS Operations Research Department. The subjects' ages ranged from 28 to 45, with an average age of 33.

Seventeen of the subjects were enrolled in the Command, Control, and Communications (C3) Curricula at NPS, while the other two students were from the Intelligence and Computer Science curriculas. The background of the subjects were quite varied: special warfare; ground combat; communications maintenance and staff; logistics staff; automatic data processing; training; intelligence; C3 research; language analysis; electronic warfare; Joint Chiefs of Staff; field artillery; destroyer group staff; combat development; C3 training and operations; and tactical C3 flight operations.

Nineteen of the subjects had experience with interactive computer systems at NPS. Eighteen of the subjects were experienced in use of the ARPANET, a network of computer systems available for use by the C3 Curricula and other researchers at NPS. The two subjects without ARPANET

experience were trained to the level necessary to participate in the experiment with their contemporaries, since a computer on the ARPANET was chosen as the host for the experiment.

The subjects were, as a whole, familiar with speech recognition as many had either seen, used, or even studied automatic speech recognition. Eighteen subjects had seen a voice recognition system demonstrated; 12 subjects had used voice, primarily as subjects in one other experiment; and 11 had studied voice for a term paper, thesis, or work at their previous duty station.

C. EQUIPMENT

1. Voice Recognition System

A Threshold Technology Inc. Model T600 voice recognition system was used to represent commercially available, state-of-the-art equipment. The T600 is a speaker-dependent, isolated-word recognizer which automatically recognizes spoken words or phrases. These words or phrases are called utterances and must be in a range of 0.1-2.0 seconds in duration and must be separated by very short pauses of 0.1 second or more [Ref. 19].

The terminal consists of a threshold analog speech preprocessor, an LSI-11 microcomputer and a digital RS-232 input/output interface, an Ann Arbor large character display and operator console, an operator console/microphone

preamplifier, and a tape cartridge unit. The speech preprocessor, microcomputer, and interfacing elements are contained in the main terminal unit which was table mounted. The remaining components, the display console, and tape were also table mounted and located with the main terminal (see Figure 7). A Shure SM-10 noise-cancelling microphone with headset was used for the voice input to the preamplifier.

The T600 combines analog and digital signal processing technology to perform the recognition function. The energy from the spoken utterance is passed through 19 bandpass filters spanning the speech spectrum. The presence or absence of each of 32 acoustic features is determined, and the appropriate feature information is extracted by a combination of analog and binary logic. The features are either primary features or phonetic-event features. Primary features describe the energy spectrum by measuring local maxima and the energy rate-of-change relative to the frequency of the voice signal. Phonetic-event features result from measurements corresponding to phoneme-like events: vowels, nasals and fricatives. The preprocessor also must determine the beginning and ending of each word.

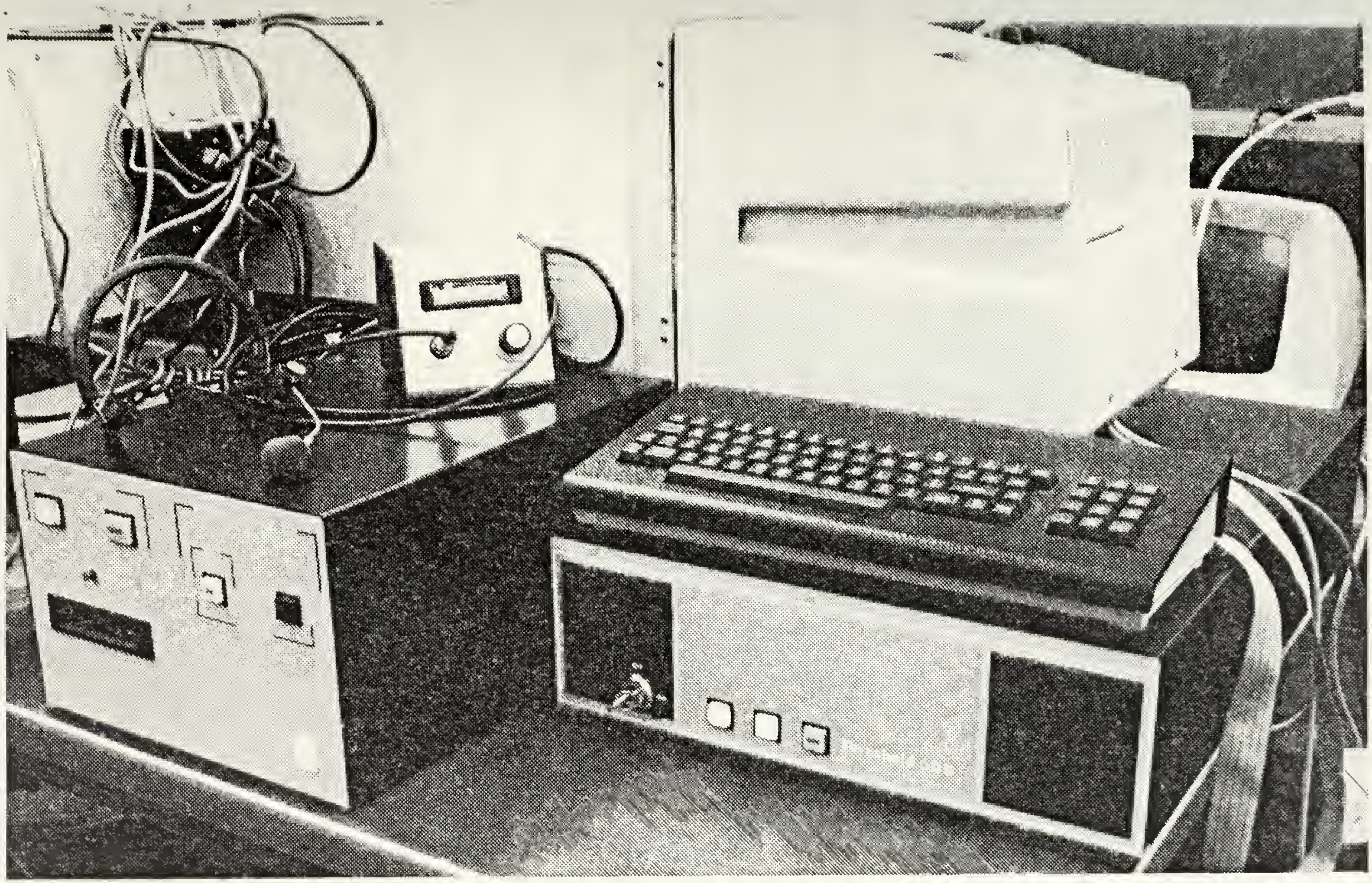

Figure 7. Threshold Technology, Inc., T600 Voice Recognition System with Ann Arbor Terminal (facing left) and Keyboard, and Shure SM-10 Microphone

The T600 has two primary modes of operation: training mode, and recognition mode. In the training mode, the T600 extracts a time-normalized template for each given word. This template consists of two arrays referred to as the most significant bit (MSB) and non extremum bit (NEB). The MSB indicates whether a particular feature has occurred and the NEB indicates the frequency of occurrence. These arrays combine to form the reference array (RAR). When the T600 is in recognition mode, the preprocessor functions as before: features are extracted, digitized, and time normalized. The resultant feature array (FAR) is correlated with the stored RARs in the current active vocabulary and the best correlation is selected as the recognized word.

As previously mentioned, for each utterance 32 acoustic features represented in binary form and their time of occurrence are fed from the preprocessor to the microcomputer short-term memory. The pattern-matching algorithm subsequently compares these feature occurrence patterns to the stored reference patterns for the various vocabulary words and determine the "best fit" for a word decision. The FAR of a test word requires 512 bits of information (32 features mapped into 16 time segments). The RARs include 1024 bits per word because of the two part arrays.

When the T600 recognizes a word in its vocabulary it will output a preprogrammed string of up to 16 characters

associated with the spoken word. These output strings can be modified by the user at any time via his ASCII console, which may also be used instead of voice to interact with the host computer. Also associated with each word are training prompts which are strings of up to 12 ASCII characters displayed on the CRT terminal to notify the user of the word to be trained. The T600 used in this experiment required 10 training utterances per word.

Two types of errors can occur with the T600: misrecognition and rejection. Misrecognition errors are those where an output string is selected for output that does not match the utterance. When the system rejects the utterance as not part of the vocabulary it signals the operator with a "beep." These two cases assume the word was in the vocabulary and properly trained. Other errors are called operator errors and arise from mispronunciation, using words not in the vocabulary, or a variety of other errors such as speaking too fast or slow.

The T600 used had enough memory modules to maintain an active working vocabulary of 256 utterances. Vocabularies were input and output using the tape cartridge unit. The system reads and stores prompt and output strings and reference patterns from semiconductor random access memory onto rugged, high-quality magnetic tapes similar to cassette tape cartridges. A complete 256 word vocabulary may be recorded or loaded in a few minutes.

Two recognition modes are available on the T600: unbuffered and buffered. In unbuffered mode, the T600 will send any output immediately to the host computer. No internal processing is performed on the output strings. However, the buffered mode permits up to 128 utterance output strings to be sequentially stored in a T600 buffer for subsequent output as a composite block of characters. An "erase function" may be used to delete the last utterance; an "interrupt" function sends a special user-defined string to the host and deletes the remainder of the buffer contents; a "cancel" function may be used to delete the buffer contents; and a "transmit" function will cause the T600 to send the buffer contents to the host. The utterance assigned to these functions may be independent of their function name.

2. Tachistoscope

To provide a simulation of the light table and optics portion of the imagery interpreter's work environment, the G-1130 Harvard Tachistoscope was selected from the man-machine laboratory facilities. (see Figure 8) The tachistoscope is an instrument that can present images of material presented on cards and, as modified in this experiment, a CRT display. The card images may be presented by a timer or changed at will by the subject using a button switch. Lighting may be regulated

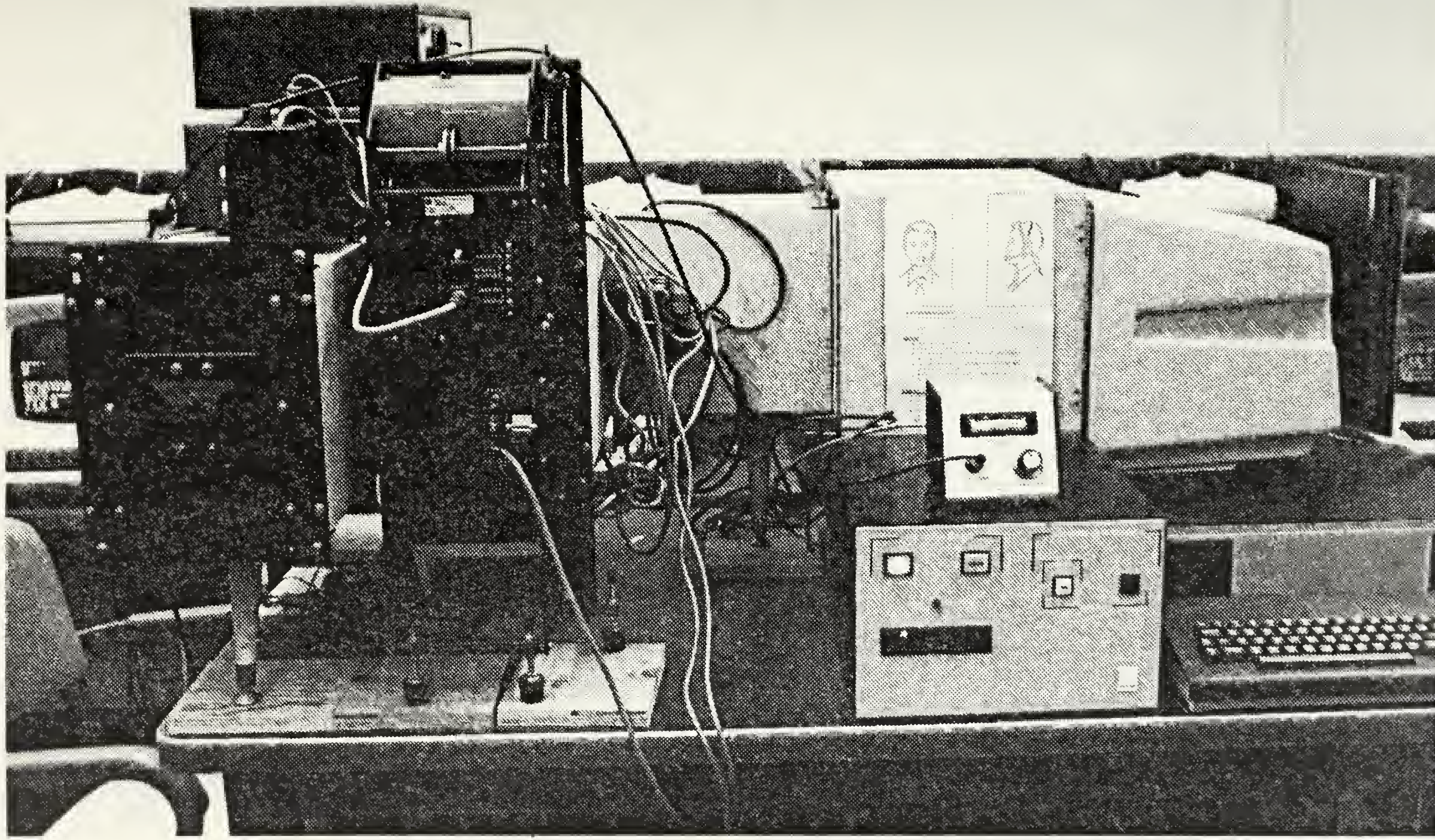

Figure 5. Tachistoscope Interfaced to Ann Arbor CRT Display and Motorized Card Presentation Peripheral

and multi-images overlayed. The three primary uses of the device are studies on learning, perception, and attention [Ref. 20].

However, in this experiment the tachistoscope was used in the following manner. The viewport seen in Figure 9 simulates the optics through which an interpreter must get much of his/her data. The 4" x 6" cards seen through it simulated the imagery the interpreter was tasked to analyze and report. The CRT presented three lines of data (40 characters each) providing visual feedback for voice data entry. (Note: Rome Air Development Center has developed an eyepiece for a Bausch & Lomb stereoscope that displays 16 characters of data while viewing the optics; thus the author assumed that more data could be displayed in the next few years to support such visual feedback, if required.)

The tachistoscope viewport permitted the viewing of the scenario cards and the Ann Arbor CRT. The card image was centered above the three bottom lines of the large-character CRT. The CRT displayed the responses of the T600 to the subject's utterances, thereby providing visual feedback to him/her performing the task.

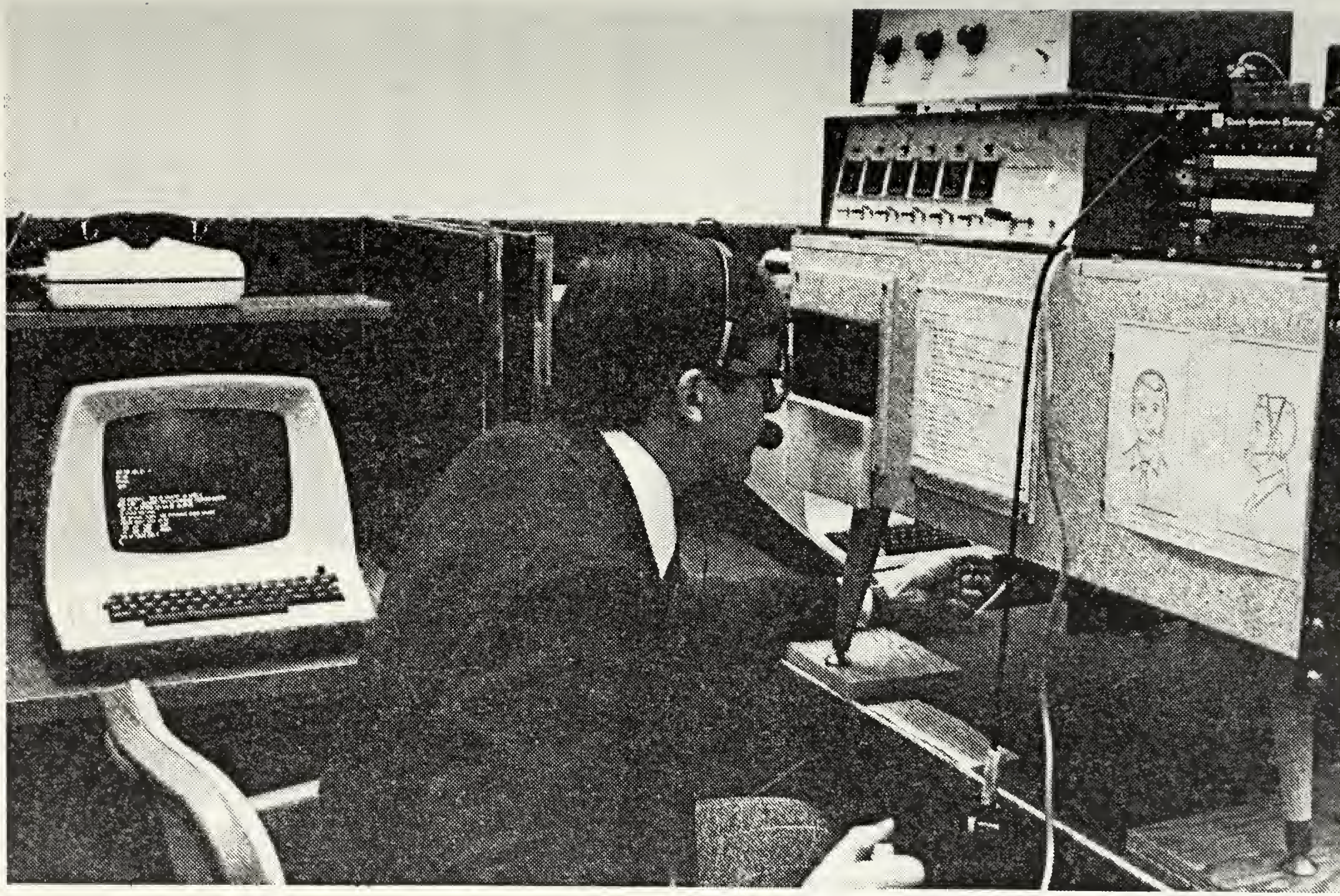

Figure 9. Tachistoscope Viewport
Used to Simulate Optics and Light Table

3. Scenario Cards and Vocabulary

The cards for the reporting scenario were used to simulate frames of imagery. Because no imagery interpreters were available in large numbers for the experiment at NPS, the author created the cards with a "**" to represent the equipment location and annotated the "**" with the number and description of the equipment at the point. All subjects were provided with the same information, i.e. they were "perfect imagery interpreters" and any experience level was held constant.

Figure 10 illustrates the format of two sample cards which had five to eight objects and an installation number. Each card was divided into four quadrants to simplify and standardize the reporting process and scoring.

Thirty-six cards were required for the experiment. Their content was governed by four criteria: realism, an even mix of ground, air, and naval terms, full use of the USSR/Warsaw Pact vocabulary selected for the experiment, and maintaining a balance in number of characters among sets of cards to be used in experimental trials. The cards used in the experiment are shown in reduced size in Appendix B. The larger, actual size cards seen in Figure 10 were produced using large print on a Tektronix 4014 terminal and its associated thermal printer.

```
INSTALLATION 0298-T14217
                                     **
50 CONFIRMED ASU-85 AIRBORNE ASSAULT GUNS

27 CONFIRMED ASU-57 AIRBORNE ASSAULT GUNS
**

 ** 20 POSSIBLE M-20 HEAVY MORTARS

62 PROBABLE 122-MM D-30 FIELD HOWITZERS **

48 CONFIRMED 240-MM BM-24 ROCKET LAUNCHERS

                 **
```

```
INSTALLATION 0199-V14197
                              **
  16 CONFIRMED MI-4_HOUND HELICOPTERS

                         **
11 CONFIRMED MI-12_HOMER HELICOPTERS

** 5 PROBABLE MI-6_HOOK HELICOPTERS

                           **
    21 CONFIRMED MI-10_HARKE HELICOPTERS

                      **
      19 PROBABLE MI-24_HIND HELICOPTERS
```

Figure 12. Sample Scenario Cards
(actual size = 4" X 6" including border)

A USSR/Warsaw Pact vocabulary was used because of available unclassified source information in large quantity [Refs. 21, 22, 23, and 24]. A full vocabulary of 255 words was used containing the phonetic alphabet, numbers 0-25, administrative alphanumerics, special symbols and control characters, and ground, air, and naval forces equipment vocabulary. Appendix A contains a complete listing of the vocabulary by number, training prompt, and output string.

The vocabulary was not structured in terms of recognition sets. Rather, the T600 operated on the entire vocabulary each time an utterance was spoken.

4. Interactive Computer System: ARPANET

To provide an interactive text editing environment for the reporting scenario, the facilities of the ARPANET were selected because of their reliability and also to demonstrate how reporting might be done over a distributed network of computers, rather than a local host system. The ARPANET, now managed by the Defense Communications Agency, was used by 18 of the subjects during 5 quarters of their C3 Curricula prior to the experiment.

Two host computers were used: Information Sciences Institute Systems E and C (ISIE & ISIC), located in southern California. The experimental text editor (XED), photoscript (PHOTO), directory linking (TALK), file transfer protocol (FTP), and file archival (ARCHIVE) were the major programs

used to conduct and manage the experimental data and interactive computer environment. ISIC was the primary system used, because the "system load level" was generally lower thereby offering a more responsive system. The load level was checked during experimentation to assure a consistent response time was available to all subjects. Both systems were supported by the TOPS-20 Operating System, on Digital Equipment Corporation (DEC) Model 20 Computers.

These computers were linked to NPS terminals equipped with phone modems or acoustic couplers via the ARPANET distributed communications facilities. These facilities include a terminal interface processor (TIP) at NPS connecting school terminals with ISI via the ARPANET. The author gained access to the network via the TIP and selecting the network computer to be used. The ARPANET provided a myriad of facilities supporting the administration of the experiment. Figure 11 is a map of the ARPANET adapted from the ARPANET Information Brochure, 1979.

CRT terminals and the T600 were attached to the ARPANET via 300 bps acoustic couplers. A Lier-Siegler ADM CRT display was situated near the tachistoscope to provide keyboard entry of the OB data obtained from the cards via the viewport (see Figure 12). The ADM terminal on

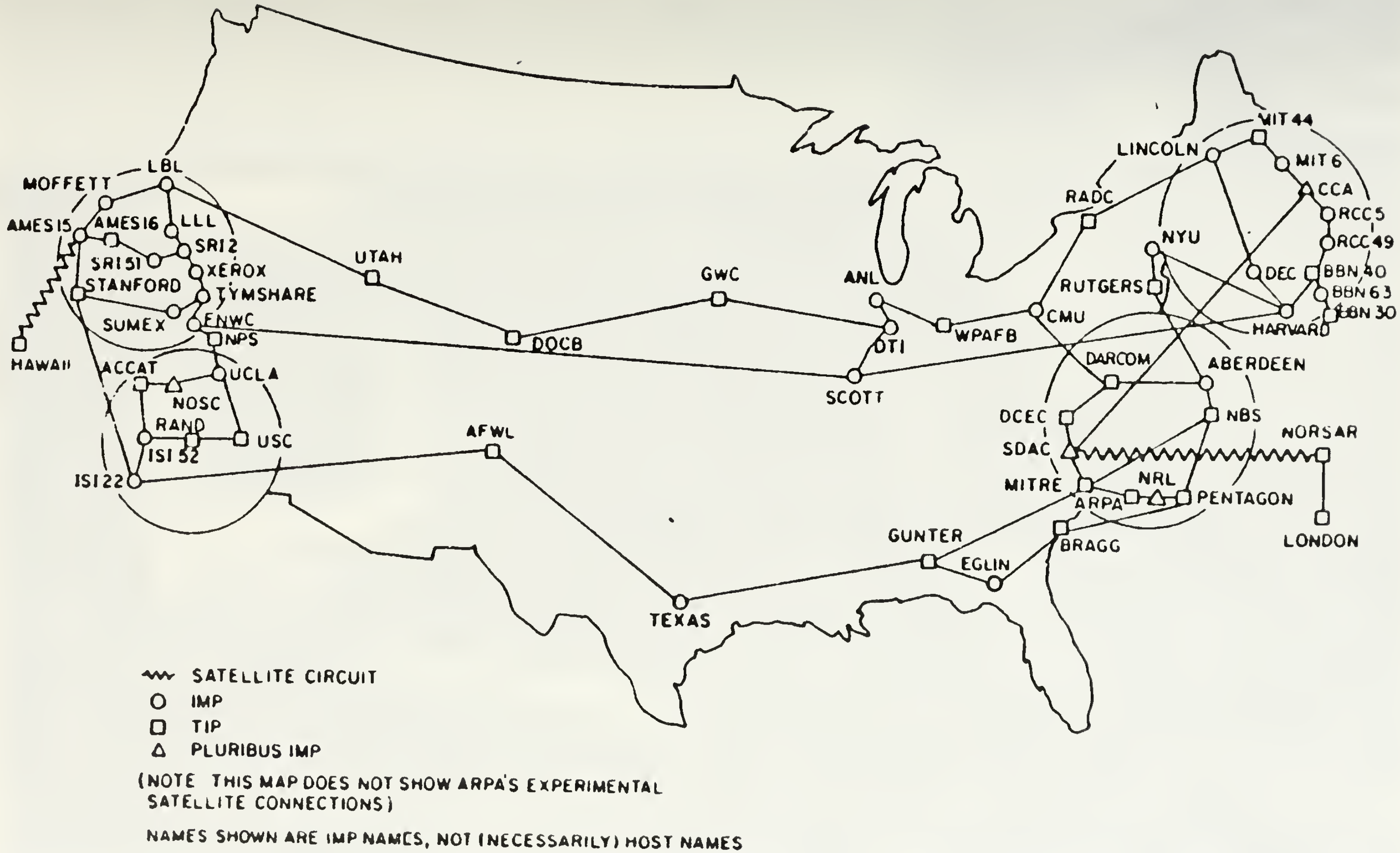

Figure 11. ARPANET MAP

(December, 1978)

Figure 12. ADM Terminal

Attached to ISI Computer via the ARPANET

the ARPANET was used to simulate the text editing facilities of an imagery reporting system for the order of battle entry portion of the report. All keystroke entries into the terminal were copied by a typescript program during the experiment to provide a record of the subject's performance.

A monitor station with a hardcopy Computer Devices Miniterm and an Alanthus V-203 CRT display were used to record and observe the subject's actions, whether by voice or keyboard entry (see Figure 13). The Alanthus display, connected to the T600, provided the author with a copy of the data being displayed to the operator via the Ann Arbor display used in the tachistoscope viewport for visual feedback. This was essential for recording, recognition and rejection errors in the voice-buffered mode; such errors could not be analyzed from the hardcopy record if edited from the voice buffer prior to transmission of the buffer contents to the text editor.

D. SUBJECT PREPARATION

1. T600 Vocabulary Training

Prior to the experiment, subjects were individually trained in the use of the T600 to a level of knowledge and competence to allow them to operate it to train the large vocabulary of 255 words. Each subject was briefed on the

V-223 CRT　　　　Miniterm hardcopy terminal

Figure 13. Monitor Station

proper training of the T600, and received a demonstration and written instructions with the training (see Appendix C). Once the subject had demonstrated proficiency in operating and training the T600, he/she was allowed to proceed independently, with the author remaining nearby to answer questions and correct training pitfalls. Once training was complete, the subject tested the vocabulary by saying each word three times. Any words which were misrecognized or rejected more than once were retrained until a good training pattern was established. Most retraining was required because the subject forgot how the word was pronounced when initially trained.

The training was normally accomplished in two sessions of approximately two hours each. Thus by the time the training was complete, the subject was very familiar with the T600. Approximately four hours was the average time each subject spent with the vocabulary prior to experimentation. The training patterns were stored on a cassette tape for each subject and retained by the author until experimentation.

2. Typing Test

A five minute typing test was given to each subject to group the subjects into "FAST" and "SLOW" typing ability groups; these groups were necessary for the experimental design. The typing test required only upper case letters and symbols (Appendix D), as did the experiment.

The typing test was administered and scored similarly to the civil service test used to screen clerk-typist applicants to determine their typing ability. The typing tests were scored for speed and accuracy. A raw score in words per minute was assigned according to the number of lines typed. Credit was given for all lines typed, including any portion of the last line started. The number of words per minute was based on an average word length of five characters. For each mispelled word, 0.2 words per minute were subtracted from the raw score, thereby decreasing the final score to deduct for errors. For example, if a subject had a raw score of 40 wpm, but made 5 typing errors, the final score would be 39 wpm.

Subject typing speeds ranged uniformly from 17 to 58 words per minute, with an average speed of 43 words per minute. The SLOW typist scores ranged from 17 to 32 with an average of 25; FAST typists scores ranged from 33 to 58 with an average of 43.

3. Subjective Questionnaire and Data Sheet

To assess the attitudes of each subject before and after experimentation regarding their assessment of voice data entry versus typed data entry, a 10 item subjective questionnaire was developed (see Appendix E). The questionnaire asked for the subject's opinions regarding the

voice and typing modes on concerns relating to usability such as speed, accuracy, flexibility, training, and other criteria.

Subjects also completed a short data sheet regarding age, previous job, background, next assignment, and voice experience. Appendix F contains the data sheet format.

E. EXPERIMENTAL PROCEDURE

As soon as the subject completed the vocabulary training, he/she was scheduled to perform the experiment which lasted between two and four hours, depending on the speed of the subject. The experiments were conducted in the NPS Man-Machine Lab at times most convenient to the subject, generally in the evening.

The subject was briefed concerning the general purpose for the experiment and the three major parts of the experiment: typing mode, voice-unbuffered mode, and voice-buffered mode experimental conditions (see Appendix G). Each experimental condition consisted of a practice card and three trials. A Latin-Square determined the order of the experimental conditions such that a balance was maintained in the numbers of people starting each experimental mode. This balance was also maintained on the second and third experimental conditions for the subjects. In other words, care was taken that no experimental condition received an

advantage from always being first, second, or third. Subjects were assigned randomly to the orderings.

The subject's task for each data entry mode was to write 12 simplistic on-line imagery interpretation reports of the USSR/Warsaw Pact OB obtained from the cards by looking through the viewport of the tachistoscope. Four cards were included per trial for the three trials per mode.

Recall the sample cards in Figure 10; they were used for typing (top) and voice (bottom) modes respectively, and differed slightly. Since some utterances were actually two or three words, (e.g. MIG-25 FOXBAT) and since the vocabulary of equipment names were so large, it was unrealistic to expect the subject to recall which ones were multiple words without greater familiarity with the vocabulary. A convention was adopted to link such words with an underscore symbol (_), such as MIG-25_FOXBAT, to remind the subject that the name was to be said in a single utterance vice two or three utterances. The underscore was the only distinction between the cards for voice and typing modes.

The report format is shown in Figure 14. The subject was required to report the installation number and OB location (**) by quadrant in the order shown: UPPER LEFT, UPPER RIGHT, LOWER LEFT, LOWER RIGHT. Reports were to be separated by a blank line.

INSTALLATION 0298-T14217
UPPER LEFT
27 CONFIRMED ASU-57 AIRBORNE ASSAULT GUNS
UPPER RIGHT
50 CONFIRMED ASU-85 AIRBORNE ASSAULT GUNS
LOWER LEFT
20 POSSIBLE M-20 HEAVY MORTARS
48 CONFIRMED 240-MM BM-24 ROCKET LAUNCHERS
LOWER RIGHT
62 PROBABLE 122-MM D-30 FIELD HOWITZERS

INSTALLATION 0199-V14197
UPPER LEFT
11 CONFIRMED MI-12 HOMER HELICOPTERS
5 PROBABLE MI-6 HOOK HELICOPTERS
UPPER RIGHT
16 CONFIRMED MI-4 HOUND HELICOPTERS
LOWER LEFT
19 PROBABLE MI-24 HIND HELICOPTERS
LOWER RIGHT
21 CONFIRMED MI-10 HARKE HELICOPTERS

Figure 14. OB Reporting Format Based on Cards in Figure 10

Subjects were allowed short breaks between trials and longer breaks between the entry modes as they moved for example from the typing portion to the voice-unbuffered portion or vice-versa.

The number of characters per trial was balanced to a very high degree within 10-15 characters and 10-15 utterances for all modes. The average number of keystrokes per trial for the typing mode was 1170. The average number of utterances per trial for the voice-unbuffered mode was 220/trial, slightly less than the 228/trial for voice-buffered. These keystrokes and utterances did not count any editing keystrokes or utterances, but included all carriage returns required. To perform the 3 modes x 3 trials, a minimum of approximately 3510 keystrokes and 1344 utterances would be required, plus any editing.

Prior to beginning each experimental condition the subject was briefed on the entry mode, reminded of the editing features available (delete character, delete word, delete line, and repeat line), and allowed to practice the entry mode by writing a report for a practice card.

The experimenter monitored the entire experiment at the station illustrated in Figure 13. The elapsed time to complete each trial was measured using a digital stopwatch and recorded. The Miniterm provided a typescript for analysis of the reports for missing or extra information, resulting from typing or voice recognition errors. Extra

typing keystrokes or voice utterances used for editing out errors were noted for subsequent analysis for an efficiency measurement. The CRT display was used for the unbuffered voice mode to record the misrecognitions and rejects since they did not appear on the typescript if they were edited prior to buffer transmission.

At the conclusion of the experiment the subject completed the subjective questionnaire again. The subject was asked not to discuss the experiment with others.

F. DEPENDENT VARIABLES

The following variables were recorded or calculated in per cent for each trial:

$$\text{Report Accuracy (RA)} = \frac{NCC}{NCC + OE + CE} \times 100$$

where NCC: Number of Characters Correct
OE: Omission Errors/missing data
CE: Commission Errors/extra data

$$\text{Mode Efficiency (ME)} = \frac{NCK/U}{NCK/U + EK/U + EDK/U} \times 100$$

where NCK/U: Number of Correct Keystrokes/Utterances (Typing/Voice)
EK/U: Error Keystrokes/Utterances
EDK/U: Editing Keystrokes/ Utterances used to recover errors

$$\text{Recognition Accuracy (RA)} = \frac{NCR}{NCR + NM} \times 100$$

where NCR: Number of Correct Recognitions
NM: Number of Misrecognitions

$$\text{Recognition Accuracy with Rejects (RAR)} = \frac{NCR}{NCR + NM + NR} \times 100$$

where NCR: Number of Correct Recognitions
NM: Number of Misrecognitions
NR: Number of Rejects

Perhaps the most important variable was the time it took for a subject to complete the trials in the experiment. Close behind time is accuracy, since reports must be valid in addition to timely. Thus it is important to look at report output in terms of accuracy as a system product. Frequently experimenters examine the errors made with voice and typing and report the results as percentage of error. However in this experiment the final test is in the report produced . . . is it accurate? Next, how efficient is the data entry mode? This is also a useful statistic for judging the merits of each system. Accuracy and efficiency were basic measures of the total system capability, i.e. the man and the machine. Recognition accuracy was a measure of T600 performance alone, with operator errors such as mispronunciation removed. Two recognition accuracy measures were examined, but the first is considered most appropriate in this experiment since the T600 did not output incorrect

data but "beeped" when it rejected what should have been a valid vocabulary utterance.

G. HYPOTHESES

The following hypotheses were tested:

1. Hypotheses Regarding TIME

   a. H_0 : There is no difference in TIME to complete reports between FAST and SLOW typists.

      H_1 : H_0 false.

   b. H_0 : There is no difference in TIME to complete reports among the THREE DATA ENTRY MODES.

      H_1 : H_0 false.

   c. H_0 : There is no difference in TIME to complete reports among the THREE TRIALS.

      H_1 : H_0 false.

2. Hypotheses Regarding ACCURACY

   a. H_0 : There is no difference in ACCURACY of reports between FAST and SLOW typists.

      H_1 : H_0 false.

   b. H_0 : There is no difference in ACCURACY of reports among the THREE DATA ENTRY MODES.

      H_1 : H_0 false.

c. H_0 : There is no difference in ACCURACY of reports among the THREE TRIALS.

H_1 : H_0 false.

3. <u>Hypotheses Regarding EFFICIENCY</u>

a. H_0 : There is no difference in EFFICIENCY between FAST and SLOW typists.

H_1 : H_0 false.

b. H_0 : There is no difference in EFFICIENCY among the THREE DATA ENTRY MODES.

H_1 : H_0 false.

c. H_0 : There is no difference in EFFICIENCY among the THREE TRIALS.

H_1 : H_0 false.

4. <u>Hypotheses Regarding T600 RECOGNITION ACCURACY WITHOUT REJECTS</u>

a. H_0 : There is no difference in RECOGNITION ACCURACY between FAST and SLOW typists.

H_1 : H_0 false.

b. H_0 : There is no difference in RECOGNITION ACCURACY among the TWO VOICE MODES.

H_1 : H_0 false.

c. H_0 : There is no difference in RECOGNITION ACCURACY among the THREE TRIALS.

H_1 : H_0 false.

5. Hypotheses Regarding T600 RECOGNITION ACCURACY WITH REJECTS

a. H_0 : There is no difference in RECOGNITION ACCURACY WITH REJECTS between FAST and SLOW typists.

H_1 : H_0 false.

b. H_0 : There is no difference in RECOGNITION ACCURACY WITH REJECTS among the TWO VOICE MODES.

H_1 : H_0 false.

c. H_0 : There is no difference in RECOGNITION ACCURACY WITH REJECTS among the THREE TRIALS.

H_1 : H_0 false.

6. Hypothesis Regarding SUBJECT ATTITUDES

H_0 : There is no difference in SUBJECT ATTITUDES regarding a preference for VOICE DATA ENTRY over TYPED DATA ENTRY after the experiment.

H_1 : H_0 false.

H. EXPERIMENTAL DESIGN

The conceptual design for the experiment is illustrated in Figure 15. This is a three-factor nested design with repeated measures over trials. The subject is nested within only one typing ability condition. Recall that one-third of

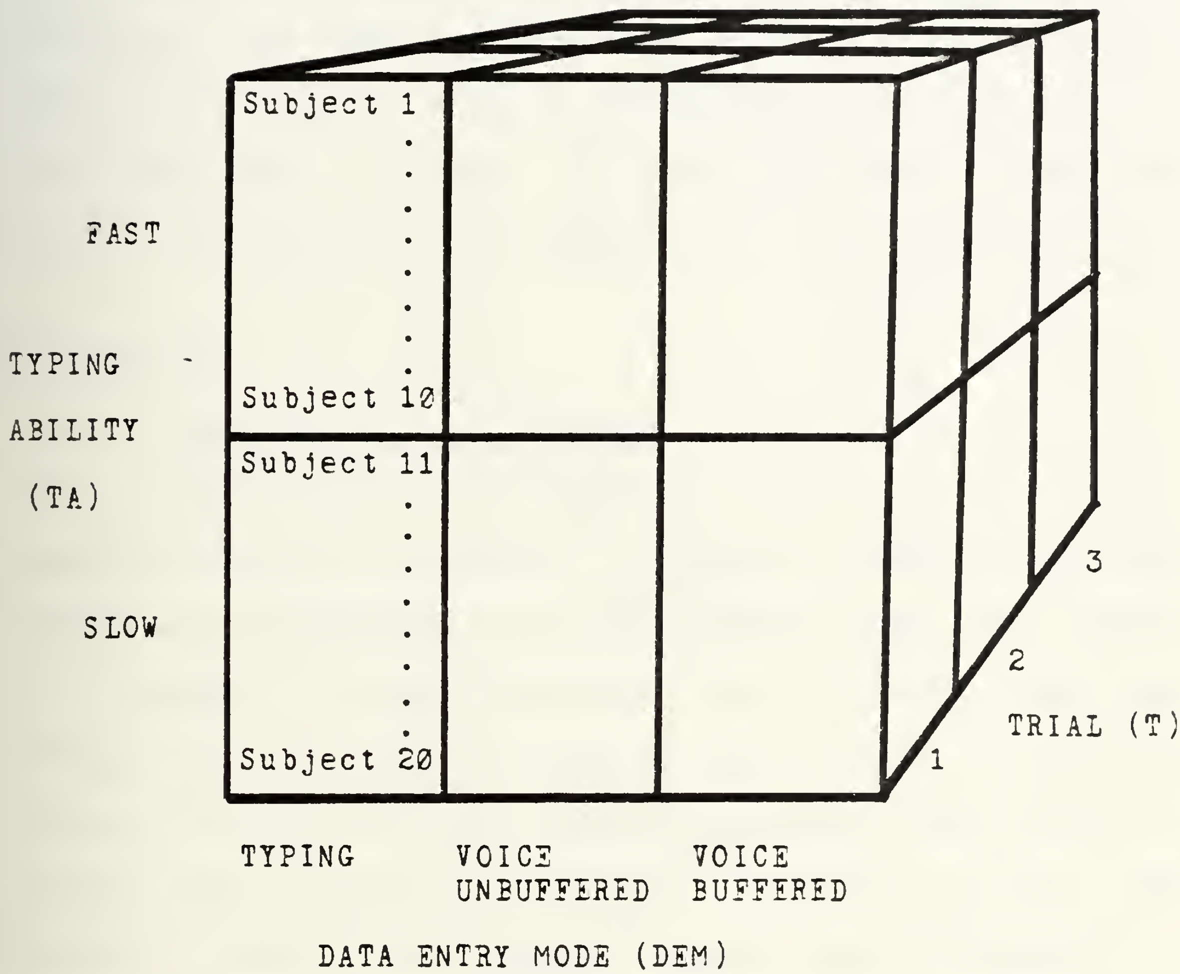

Figure 15. Conceptual Design of the Experiment

the subjects started typing first; another third started voice-unbuffered first, and another third started voice-buffered first.

An analysis of variance procedure was selected to test the hypotheses for reporting times, accuracy, and efficiency, and T600 recognition rates. A significance level of $\alpha = 0.05$ was used as the experimental threshold. A sign test was chosen to evaluate the subjective questionnaire results at a significance level of $\alpha = 0.10$.

I. RESULTS

1. Results for Reporting Time

The results for reporting time were the most significant, with an analysis of variance (ANOVA) indicating SIGNIFICANT DIFFERENCES in the DATA ENTRY MODES and TRIALS ($p < .0005$). The mean reporting times in Table I show the average time in minutes to complete each of the reporting trials for each of the three data entry modes. Table II displays the results of the ANOVA for reporting time, and Figures 16 and 17 illustrate the significant differences.

On the average, voice-unbuffered was 41% faster and voice-buffered was 58% faster than typed data entry. Thus voice data entry, averaging the two modes, was 50% faster overall than typing. Voice data entry was faster because the

subject was able to simultaneously receive information through the viewport while composing the report. The feedback received on the monitor enabled immediate confirmation of the T600 response to his/her utterances. The typist, in the conventional reporting mode, was forced to return often to the viewport to get additional items of information, since there was too much to memorize. The illustrated differences may be seen in Figure 16.

Learning over trials is apparent in all three data entry modes. Figure 17 illustrates the differences in time to complete the scenario by trials. No significant differences were noted between typing abilities. All subjects adapted to the reporting task well. The voice-buffered mode was the most natural for subjects to use, since they could simply speak the report into the system, and make corrections most easily. Thus they learned to use it quickly, and improved slightly thereafter. The voice-unbuffered and typing modes, with more room for improvement, showed more learning as the subjects adapted to the reporting scenario.

No significant difference was apparent between fast and slow typists for this experiment. This was primarily because the amount of information that the subject could get from the tachistoscope was limited to the amount he/she could memorize when moving back and forth to the manual keyboard.

TABLE I

MEAN REPORTING TIME (MINUTES)

	TYPING	VOICE UNBUFFERED	VOICE BUFFERED
FAST TYPISTS			
Trial 1	16.2	11.6	10.5
Trial 2	13.6	10.5	10.1
Trial 3	13.2	9.6	9.1
All Trials	14.3	10.6	9.9
SLOW TYPISTS			
Trial 1	18.0	12.7	10.0
Trial 2	16.5	10.8	9.8
Trial 3	15.6	10.5	9.2
All Trials	16.7	11.3	9.7
ALL SUBJECTS			
Trial 1	17.1	12.2	10.3
Trial 2	15.1	10.7	10.0
Trial 3	14.4	10.1	9.2
All Trials	15.5	11.0	9.8

For the following analysis of variance several abbeviations are used for the sake of brevity. Their meaning is expanded below:

SS: Sum of Squares
df: degrees of freedom
MS: Mean Square
F: F Ratio
p: significance level

TABLE II

ANALYSIS OF VARIANCE FOR REPORTING TIME (SECONDS)

SOURCE	SS	df	MS	F	p
BETWEEN SUBJECTS:	3,588,801.60	19			
Typing Ability (TA)	149,472.05	1	149,492.05	0.78	NS
Error	3,439,329.61	18	191,073.87		
WITHIN SUBJECTS:	6,588,801.20	160			
Data Entry Mode (DEM)	3,969,141.28	2	1,984,570.64	61.61	**
TA x DEM	187,215.63	2	93,607.82	2.91	NS
Error(1)	1,159,579.54	36	32,210.54		
Trials (Tr)	424,888.41	2	212,444.21	33.22	**
TA x Tr	2766.70	2	1,383.35	0.22	NS
Error(2)	230,255.50	36	6,395.99		
DEM x Tr	66,396.02	4	16,599.01	2.28	NS
TA x DEM x Tr	17,872.27	4	4,468.07	0.61	NS
Error(3)	525,207.79	72	7,294.55		
TOTAL	10,172,124.80	179			

** $p < 0.0005$

[NS: NOT SIGNIFICANT for $p < 0.05$]

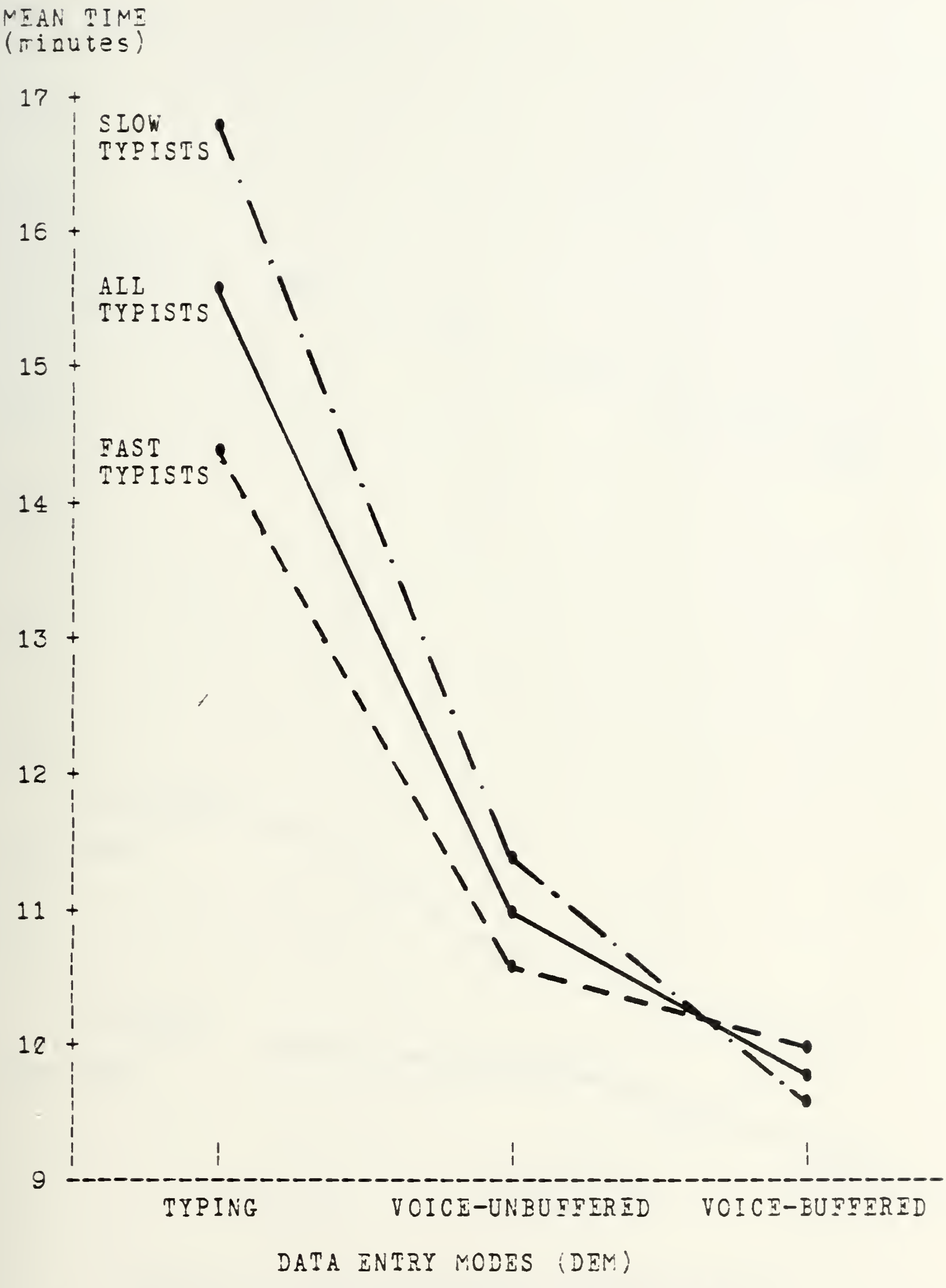

Figure 16. Mean Reporting Time by Data Entry Mode

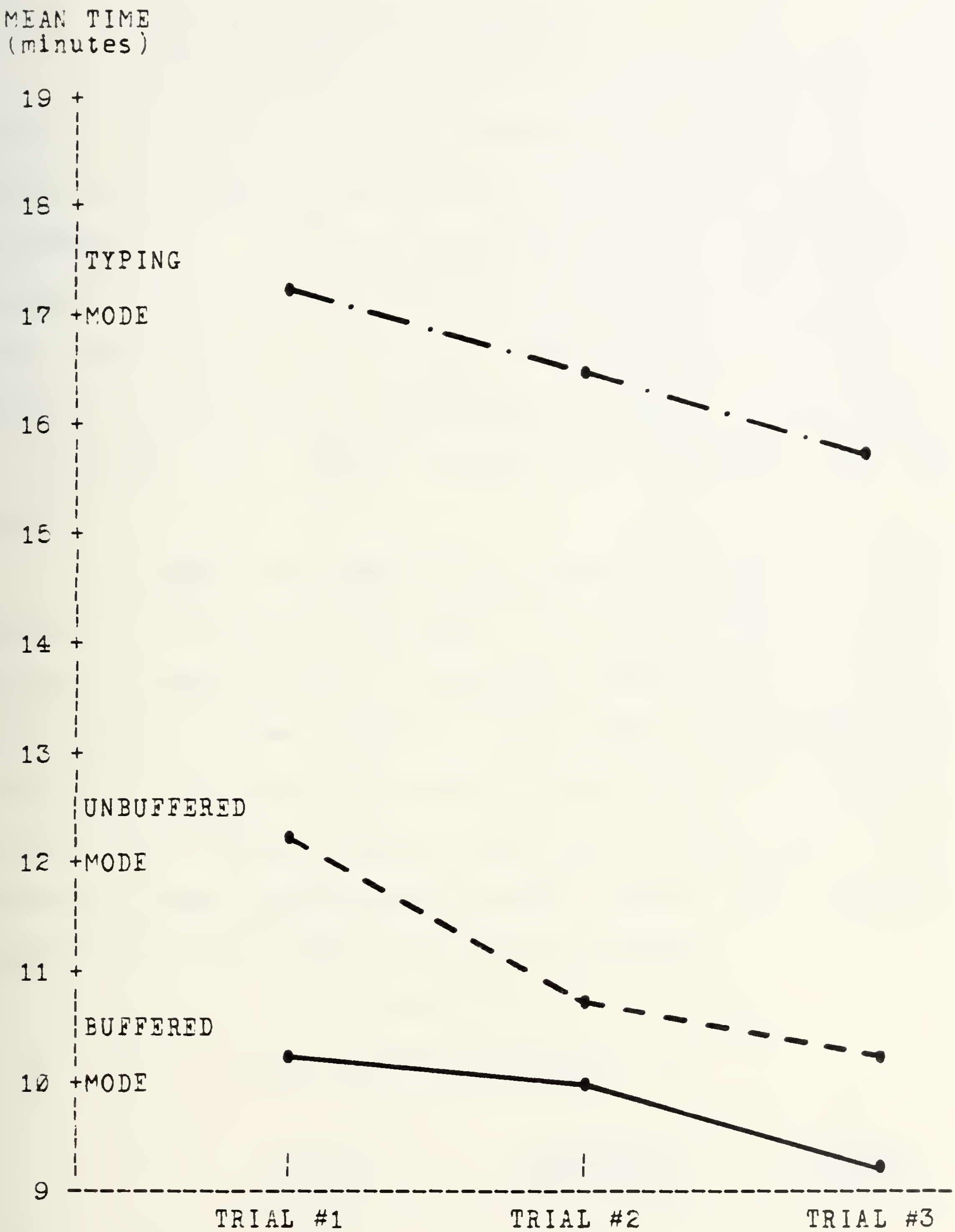

Figure 17. Mean Reporting Time by Trial

2. <u>Results for Reporting Accuracy</u>

The results for reporting accuracy are shown in Tables III and IV. The analysis of variance for the arcsin-transformed efficiency data revealed NO SIGNIFICANT DIFFERENCES in ALL CONDITIONS investigated. The subjects, whether fast or slow typists, did near perfect reporting in each mode, over all trials. The reporting accuracy was expected to be high, but exceeded the author's expectations. An average of 99.5% accuracy was achieved for the experiment.

Subjects were told to go as fast as possible, while maintaining accurate reporting. Most errors were errors of omission, where a letter or word was missing from a report. Even greater speeds could be expected, especially from voice, in situations where more errors could be tolerated. But in the case of imagery reporting, accuracy was deemed essential, even though operationally reports are normally edited before being sent out to the agencies.

TABLE III

MEAN REPORTING ACCURACY (%)

	TYPING	VOICE UNBUFFERED	VOICE BUFFERED
FAST TYPISTS	99.8	99.6	99.7
SLOW TYPISTS	99.2	99.4	99.6
ALL SUBJECTS	99.5	99.5	99.6

TABLE IV

ANALYSIS OF VARIANCE

FOR ARCSIN-TRANSFORMED REPORTING ACCURACY

Y = 2 * ARCSIN [SQRT(ACCURACY %)]

SOURCE	SS	df	MS	F	p
BETWEEN SUBJECTS:	3.788	19			
Typing Ability (TA)	0.004	1	0.004	0.02	NS
Error	3.784	18	0.210		
WITHIN SUBJECTS:	24.030	160			
Data Entry Mode (DEM)	0.346	2	0.173	1.18	NS
TA x DEM	0.407	2	0.204	1.40	NS
Error(1)	5.262	36	0.146		
Trials (Tr)	0.352	2	0.176	1.18	NS
TA x Tr	0.202	2	0.101	0.68	NS
Error(2)	5.362	36	0.149		
DEM x Tr	0.395	4	0.099	0.64	NS
TA x DEM x Tr	0.326	4	0.082	0.53	NS
Error(3)	11.078	72	0.154		
TOTAL	27.818	179			

[NS: NOT SIGNIFICANT for p < 0.05]

Note: Arcsin transform above normalizes the per cent data.

3. Results for Reporting Efficiency

The results for reporting efficiency are shown in Tables V and VI. The analysis of variance indicated SIGNIFICANT DIFFERENCES between the DATA ENTRY MODES. Figure 18 shows the differences with typing being the most efficient at 95%, voice-buffered next with an efficiency of 85%, and finally voice-unbuffered with an efficiency of 80%.

The author attributes the efficiency difference, in part, to the level of experience with the mode. The reader may recall that the subjects had, in general, extensive keyboard experience during five quarters at NPS. In comparison with typing, the subjects had very little experience with voice. It is expected that if subjects were more skilled and efficient in the use of voice data entry, the time advantages reported earlier would be even more dramatic. Voice-buffered was more efficient than voice-unbuffered because the subject could edit out an entire incorrect utterance, vice deleting it by voice a word at a time in the unbuffered mode.

TABLE V

MEAN REPORTING EFFICIENCY (%)

	TYPING	VOICE UNBUFFERED	VOICE BUFFERED
FAST TYPISTS			
Trial 1	93.6	77.2	83.5
Trial 2	95.1	80.5	85.7
Trial 3	93.8	81.6	83.3
All Trials	94.2	79.8	84.2
SLOW TYPISTS			
Trial 1	94.4	80.0	86.3
Trial 2	95.8	84.4	84.4
Trial 3	96.7	76.9	88.4
All Trials	95.6	80.4	86.4
ALL SUBJECTS			
Trial 1	94.0	78.6	84.9
Trial 2	95.4	82.5	85.0
Trial 3	95.3	79.3	85.8
All Trials	94.9	80.1	85.2

TABLE VI

ANALYSIS OF VARIANCE

FOR ARCSIN-TRANSFORMED REPORTING EFFICIENCY

Y = 2 * ARCSIN [SQRT(EFFICIENCY %)]

SOURCE	SS	df	MS	F	p
BETWEEN SUBJECTS:	3.059	19			
Typing Ability (TA)	0.134	1	0.134	0.82	NS
Error	2.925	18	0.163		
WITHIN SUBJECTS:	13.689	160			
Data Entry Mode (DEM)	7.102	2	3.551	44.95	**
TA x DEM	0.023	2	0.011	0.14	NS
Error(1)	2.860	36	0.079		
Trials (Tr)	0.170	2	0.085	3.54	NS
TA x Tr	0.020	2	0.010	0.42	NS
Error(2)	0.860	36	0.860		
DEM x Tr	0.167	4	0.042	1.40	NS
TA x DEM x Tr	0.301	4	0.075	2.50	NS
Error(3)	2.186	72	0.030		
TOTAL	16.748	179			

** p < 0.001

[NS: NOT SIGNIFICANT for p < 0.05]

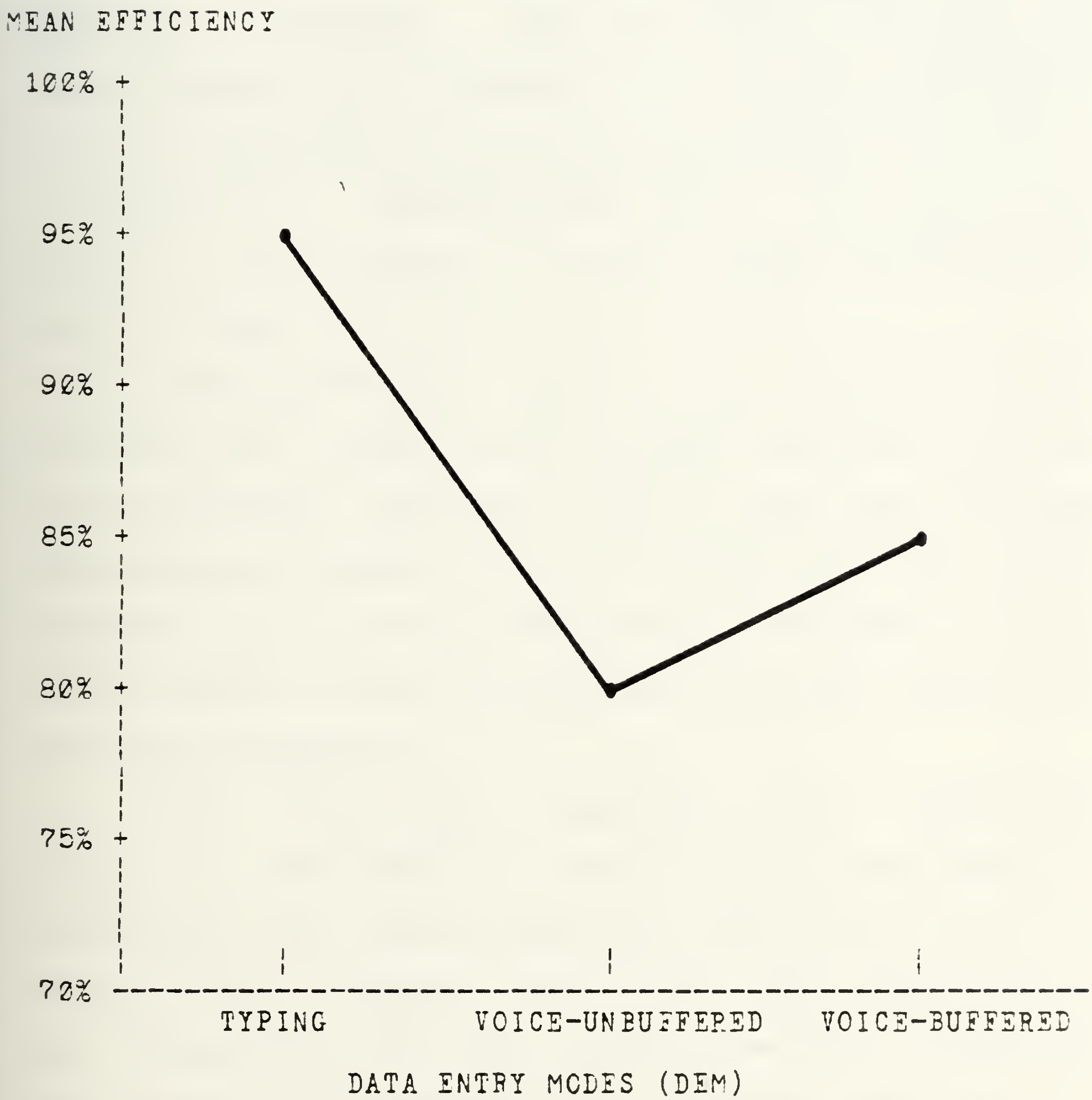

Figure 18. Mean Reporting Efficiency by Data Entry Mode

4. <u>Results for T600 Recognition Accuracy</u>

The results for the T600 Recognition Accuracy are shown in Tables VII, VIII, IX, and X. Analysis of variance of the results revealed NO SIGNIFICANT DIFFERENCES for ALL CONDITIONS considered. Thus the T600 recognized all subjects equally well during all trials of the experiment. The T600 recognition accuracy was 97.0% overall if an error is defined as a misrecognition only. If rejects are included, the recognition accuracy drops to 95.5% as an overall average.

These results are based on an average of 1519 utterances per subject giving 30,380 utterances for the entire experiment using 20 subjects. This number includes the utterances required, plus misrecognitions and reject utterances, and finally the editing utterances used to correct errors. A list of misrecognitions and rejects is contained in Appendix H.

The author had expected the recognition accuracy to get worse in later trials from fatigue or frustration, since the experiment was two to four hours in length. One procedure that may have helped was to allow subjects to, upon their request, retrain troublesome words during the course of the experiment. The time to retrain was counted against the trial time to account for realistic retraining that would take place on the job.

TABLE VII

MEAN T600 RECOGNITION ACCURACY (%)

WITHOUT REJECTS

	VOICE UNBUFFERED	VOICE BUFFERED
FAST TYPISTS	97.0	97.1
SLOW TYPISTS	97.0	96.9
ALL SUBJECTS	97.0	97.0

TABLE VIII

MEAN T600 RECOGNITION ACCURACY (%)

WITH REJECTS

	VOICE UNBUFFERED	VOICE BUFFERED
FAST TYPISTS	95.8	95.4
SLOW TYPISTS	95.2	95.4
ALL SUBJECTS	95.5	95.4

TABLE IX

ANALYSIS OF VARIANCE

ARCSIN-TRANSFORMED T600 RECOGNITION ACCURACY
WITHOUT REJECTS

Y = 2 * ARCSIN [SQRT(ACCURACY %)]

SOURCE	SS	df	MS	F	p
BETWEEN SUBJECTS:	0.864	19			
Typing Ability (TA)	0.001	1	0.001	0.02	NS
Error	0.863	18	0.048		
WITHIN SUBJECTS:	1.033	100			
Data Entry Mode (DEM)	0.000	1	0.000	0.00	NS
TA x DEM	0.009	1	0.009	0.69	NS
Error(1)	0.231	18	0.013		
Trials (Tr)	0.009	2	0.005	0.63	NS
TA x Tr	0.037	2	0.019	2.38	NS
Error(2)	0.281	36	0.008		
DEM x Tr	0.053	2	0.027	2.45	NS
TA x DEM x Tr	0.032	2	0.016	1.45	NS
Error(3)	0.381	36	0.011		
TOTAL	1.897	119			

[NS: NOT SIGNIFICANT for p < 0.05]

TABLE X

ANALYSIS OF VARIANCE

ARCSIN-TRANSFORMED RECOGNITION ACCURACY
WITH REJECTS

Y = 2 * ARCSIN [SQRT(ACCURACY %)]

SOURCE	SS	df	MS	F	p
BETWEEN SUBJECTS:	0.926	19			
Typing Ability (TA)	0.000	1	0.000	0.00	NS
Error	0.926	18	0.051		
WITHIN SUBJECTS:	1.106	100			
Data Entry Mode (DEM)	0.000	1	0.000	0.00	NS
TA x DEM	0.004	1	0.004	0.33	NS
Error(1)	0.224	18	0.012		
Trials (Tr)	0.001	2	0.000	0.00	NS
TA x Tr	0.034	2	0.017	2.43	NS
Error(2)	0.258	36	0.007		
DEM x Tr	0.046	2	0.023	1.64	NS
TA x DEM x Tr	0.018	2	0.009	0.64	NS
Error(3)	0.521	36	0.014		
TOTAL	1.977	119			

[NS: NOT SIGNIFICANT for $p < 0.05$]

During the experiment the author observed that subjects occasionally became frustrated when the T600 was misrecognizing their utterances. This frustration appeared to, at times, generate a lack of confidence in the T600, along with a change in the overall pitch, rate, and inflection of the voice. The frustration seemed more prevalent in the unbuffered than the buffered mode. For this reason, the T600 buffered mode was expected to have a better recognition rate, since it was faster and somewhat easier to use. However the results indicate there is no difference in the recognition rate. One explanation is that subjects went faster in the buffered mode since they could correct the misrecognitions more easily. With the consequence of a misrecognition reduced, they were less afraid to make mistakes.

5. Results for Subject Attitudes

The scores from the subjective questionnaire given before and after the experiment were tested for any general change in opinion regarding voice versus typed data entry. These scores were evaluated using a two-tailed nonparametric sign test, $\alpha = 0.10$. A significant shift in favor of voice data entry over typing occured for half of the criteria covered by the questionnaire. No significant shifts toward typing resulted from the analysis. Appendix I contains the results of the pre/post questionnaire.

Summarizing the results, subjects either were neutral or favored voice before and after the experiment. After the experiment, they preferred voice even more for ease of use, speed, flexibility, intermittent use, and finally ease of learning to use as an input modality. They continued to believe that voice was a more accurate, sustaining, relaxed man-machine interface for on-line reporting of critical, time-sensitive information such as intelligence obtained in a high-pressure work environment.

The subjects' positive attitudes about voice arise from their fresh experience and observations of speech recognition equipment in the C3 Lab at NPS, where it is used with the Wargame Effectiveness Simulator (WES) with graphics and other ARPANET and laboratory facilities to demonstrate its potential for command, control, and communications applications.

III. DISCUSSION

A. GENERAL

This thesis investigated the potential application of automatic speech recognition technology to military imagery interpretation reporting. Only the order of battle portion of reporting was investigated because of limited time and resources. The overall results of the experiment are supportive of the application of voice data entry for imagery interpretation reporting systems. Voice-buffered mode was 58% faster than typing, while voice-unbuffered was 41% faster. On the average, voice was 50% faster than typing.

Voice was faster because it allowed the operator to view the image while reporting. This experiment modeled conventional imagery reporting systems where a light table is located next to a computer console. The operator must move back and forth between the light table and the console, or two operators work together, with one interpreting the imagery, and the other writing the report via the console. For these situations, it appears voice data entry would significantly improve reporting speeds and/or require only one person per station to perform the task. For newer systems with the keyboard and function keys built into a computer console with a light table or digital

display, voice may not have as significant an impact for improving reporting speeds.

Both voice and typing were very accurate for the experimental task, with no significant difference between modes and an overall accuracy of 99.5%. It is interesting to note these speeds and accuracies were obtained even though subjects were less efficient with either mode of voice. Voice-unbuffered had 80.1% efficiency, voice-buffered had 85% efficiency, and typing had 95% efficiency. These results were all attained at a significance level of x = 0.05 or better.

In terms of recognition accuracy, the results were better than the author expected. Poorer results were expected because short phrases consisting of several utterances were used rather than simple one or two utterance commands. It was anticipated that subjects would run words together more than they actually did, and it was also anticipated that the T600 would have more trouble with similar sounding terms such as MIG-25 FOXBAT and MIG-25R FOXBAT...or CHARLIE I CLASS and CHARLIE II CLASS. Though the T600 did misrecognize such words at times, subjects quickly adapted to the situation, emphasizing the portion of the utterance that was unique, thereby achieving better results. The 97% overall recognition accuracy would likely improve with practice and increased usage. Additionally, new high-speed recognition systems, like

Threshold's QUICKTALK (Trademark), require a much shorter pause between utterances, thus permitting the operator to speak faster. QUICKTALK is advertised to reach speeds of 180 words-per-minute, and 99% accuracy for moderately trained speakers. Vocabulary structuring may also be performed which allows the system to search only a subset of the vocabulary, thus increasing the speed and accuracy of recognition. This system, as advertised, has twice the speed of the T600 used in the experiment.

Subjects tended to prefer voice before and after the experiment (even more). For the vast majority of subjects, this was the first use of voice continuously for an extended period of time. Even though it did not meet some of their more lofty expectations, they continued to give voice the edge in the subjective questionnaire, and actually strengthed their opinions toward it on several criteria.

Thus this experiment, though outside an operational setting, supports further research and possible applications of ASR for imagery interpretation reporting systems, and perhaps other similar intelligence and tactical command and control data systems. The results are certainly not new, but add credence to the related results achieved by RADC, NPS, and others.

Use of the ARPANET facilities in this experiment demonstrated, to a limited degree, that reporting can be performed without the benefit of a

local host computer. This may be very beneficial in the future if department of defense organizations want to remotely query or update a common data base.

B. RECOMMENDATIONS

1. Research

The time is perhaps ripe for the military to perform some research using voice data entry as a keyboard assist for one or more of the current imagery reporting systems, such as TIPI IIS, MARRES, CATIS, PACER, AIRES, and others. By beginning now to look at the use of voice for these systems, the intelligence community may be able to identify the specific questions needing to be addressed to most fully adapt voice as an input modality. In the next five or ten years, the outlook for "matter-of-fact" use of voice is good. By studying the problems associated with training, user acceptance, physical interfacing, vocabulary size, vocabulary data-base maintenance, response times, and other areas now, voice will be more easily applied later.

Additionally, voice input may be applied to other tasks associated with the other intelligence disciplines using interactive computer-controlled devices. Command center applications are also receiving increased attention as natural language query systems coupled with graphics displays commanded by voice are now a reality in terms of advanced applications technology.

All new imagery exploitation systems being developed or modified should fully consider the benefits of voice recognition technology. Considering the three to eight years it takes to develop a new system, it is highly likely that by the time it is fielded, significantly more voice capabilities will be available. Special consideration should be given to not only to how it might aid interpreters in the reporting process, but also how they might be able to use it to enhance, manipulate, annotate, and otherwise modify digital softcopy imagery on systems such as Compass Preview.

2. Applications

Practical applications using voice data entry on a large scale will require a significant amount of work. It must also be proven that while voice may be as fast or faster than typing that the time differential achieved contributes commensurately with the additional cost of such new technology. Careful attention must be paid to involving the users, since they will ultimately "sell" the system, even though proven in the lab.

The author recommends a small application first with a few of the best interpreters who know the imagery system well, and are ambivalent regarding voice data entry. By allowing them to use voice on a daily basis, they can develop the in-house expertise at the level needed to apply it on a large scale later...or they may be able to assess

that it just won't work for that particular application.

The military is fortunate, having excellent research people involved with voice technology. RADC and NPS are just two military institutions able to provide consultation and assistance.

C. CONCLUSIONS

Since 1972, automatic speech recognition has proven to be valuable for a number of limited applications. The future for the technology is bright. The author concludes voice is not only feasible, but desirable as a means toward the best imagery interpretation reporting possible. It is not so much a question of whether voice can be used, but rather ... how can it be used?...how extensively can it be used?...and how cost-effective will it be?

APPENDIX A

USSR/WARSAW PACT ORDER OF BATTLE (OB) VOCABULARY

INSTRUCTIONS: TRAIN THE WORDS IN THE GIVEN SEQUENCE, USING THE GIVEN PROMPT. WORD NUMBERS MARKED WITH AN ASTERISK MAY BE TRAINED WITH THE GIVEN PROMPT OR YOU MAY USE YOUR OWN. (THESE WORDS WILL BE USED FOR TEXT EDITING, AND THUS SHOULD BE FAMILIAR, EASY TO REMEMBER) **** BE SURE TO WRITE IN THE ONE THAT YOU USE ON THE VOCABULARY LISTING SO THAT YOU MAY HAVE IT FOR FUTURE REFERENCE. ****

WORD	PROMPT	OUTPUT
0	ZERO	0
1	ONE	1
2	TWO	2
3	THREE	3
4	FOUR	4
5	FIVE	5
6	SIX	6
7	SEVEN	7
8	EIGHT	8
9	NINE	9
10	ALPHA	A
11	BRAVO	B
12	CHARLIE	C
13	DELTA	D
14	ECHO	E
15	FOXTROT	F
16	GOLF	G
17	HOTEL	H
18	INDIA	I
19	JULIET	J
20	KILO	K
21	LIMA	L
22	MIKE	M
23	NOVEMBER	N
24	OSCAR	O
25	POPPA	P
26	QUEBEC	Q
27	ROMEO	R
28	SIERRA	S
29	TANGO	T
30	UNIFORM	U
31	VICTOR	V
32	WHISKEY	W
33	XRAY	X

34	YANKEE	Y
35	ZULU	Z
36	POSSIBLE	_POSSIBLE_
37	PROBABLE	_PROBABLE_
38	CONFIRMED	_CONFIRMED_
39	DASH	-
4Ø*	ERASE	BKSP <CTRL A>
41	GO OR CARRIAGE RETURN	<CARRIAGE RETURN>
42	SLASH	/
43*	KILL WORD	<CTRL W>
44*	KILL LINE	<CTRL X>
45*	REPEAT LINE	<CTRL R>
46	SPACE	<SPACE CHARACTER> _
47	TEN	1Ø
48	INSTALLATION	INSTALLATION_
49	ELEVEN	11
5Ø	UPPER LEFT	UPPER LEFT
51	TANKS	TANKS_
52	LIGHT	LIGHT_
53	MEDIUM	MEDIUM_
54	HEAVY	HEAVY_
55	T72	T-72_
56	T62	T-62_
57	T54/55	T-54/55_
58	T1Ø	T-1Ø_
59	T34/85	T-34/85_
6Ø	TWELVE	12
61	PT76	PT-76_
62	AMPHIBEOUS	AMPHIBEOUS_
63	UPPER RIGHT	UPPER RIGHT
64	APC	APC
65	ATGW	ATGW
66	BRDM	BRDM
67	BTR6ØPK	BTR-6ØPK_
68	BMP76PB	BMP-76PB_
69	BTR152	BTR-152_
7Ø	BTR5ØPK	BTR-5ØPK_
71	FIELD HWTZRS	FIELD HOWITZERS
72	ASU85	ASU-85_
73	SU1ØØ	SU-1ØØ_
74	AIRBORNE	AIRBORNE_
75	LOWER LEFT	LOWER LEFT
76	D3Ø	D-3Ø_
77	AT3 SAGGER	AT-3 SAGGER_
78	ANTI-TK GUNS	ANTI-TANK GUNS
79	D74	D-74_
8Ø	D2Ø	D-2Ø_
81	M1955	M-1955_
82	D44	D-44_
83	BM21	BM-21_
84	M1976	M-1976_

85	BM24	BM-24_
86	FROG3	FROG-3_
87	FROG4	FROG-4_
88	FROG7	FROG-7_
89	SCUD A	SCUD-A_
90	SCUD B	SCUD-B_
91	SS12 SCLBRD	SS-12 SCALEBOARD
92	SSM	SSM
93	AT1 SNAPPER	AT-1 SNAPPER_
94	85 MILIMETER	85-MM_
95	100 MILIMETR	100-MM_
96	SA4 GANEF	SA-4 GANEF_
97	SA6 GAINFUL	SA-6 GAINFUL_
98	SA8 GECKO	SA-8 GECKO_
99	SA9 GASKIN	SA-9 GASKIN_
100	LAUNCHERS	LAUNCHERS
101	THIRTEEN	13
102	ASW	ASW_
103	FOURTEEN	14
104	AA GUNS	AA GUNS
105	FIELD GUNS	FIELD GUNS
106	ZU23/2	ZU-23/2_
107	ZSU23/4	ZSU-23/4_
108	ZSU57/2	ZSU-57/2_
109	S60	S-60_
110	M44	M-44_
111	M49	M-49_
112	57 MILIMETER	57-MM
113	SU15 FLAGON	SU-15 FLAGON_
114	YAK28P FRBAR	YAK-28P FIREBAR_
115	TU28P FIDLR	TU-28P FIDDLER_
116	MIG19 FARMER	MIG-19 FARMER_
117	MIG21 FSHBED	MIG-21 FISHBED_
118	MIG23 FLGGER	MIG-23 FLOGGER_
119	MIG25 FOXBAT	MIG-25 FOXBAT_
120	MIG27 FLGGER	MIG-27 FLOGGER_
121	TU20 BEAR	TU-20 BEAR_
122	TU126 MOSS	TU-126 MOSS_
123	SU9 FISHPOT	SU-9 FISHPOT_
124	MIG25R FXBAT	MIG-25R FOXBAT_
125	TU22 BLINDER	TU-22 BLINDER_
126	TU16 BADGER	TU-16 BADGER_
127	TU26 BACKFIR	TU-26 BACKFIRE_
128	MI4 HOUND	MI-4 HOUND_
129	MI12 HOMER	MI-12 HOMER_
130	MI6 HOOK	MI-6 HOOK_
131	MI8 HIP	MI-8 HIP_
132	MI10 HARKE	MI-10 HARKE_
133	MI24 HIND	MI-24 HIND_
134	IL38 MAY	IL-38 MAY_
135	M-4 BISON	M-4 BISON_

136	SU19 FENCER	SU-19 FENCER_
137	FIFTEEN	15
138	AN8 CAMP	AN-8 CAMP_
139	AN12 CUB	AN-12 CUB_
140	AN22 COCK	AN-22 COCK_
141	AN26 CURL	AN-26 CURL_
142	KA15 HEN	KA-15 HEN_
143	KA18 HOG	KA-18 HOG_
144	KA25 HORMONE	KA-25 HORMONE_
145	IL12 COACH	IL-12 COACH_
146	IL14 CRATE	IL-14 CRATE_
147	IL28 BEAGLE	IL-28 BEAGLE_
148	IL76 CANDID	IL-76 CANDID_
149	AWACS	AWACS
150	BE12 MAIL	BE-12 MAIL_
151	TRANSPORTS	TRANSPORTS
152	FIGHTERS	FIGHTERS
153	BOMBERS	BOMBERS
154	FIGHTER-BMRS	FIGHTER-BOMBERS
155	STRIKE/ATTCK	STRIKE/ATTACK
156	HELICOPTERS	HELICOPTERS
157	RECONNAISNC	RECONNAISSANCE
158	SS	SS
159	FRIGATE	FRIGATE
160	SSB	SSB
161	SSGN	SSGN
162	SSBN	SSBN
163	CARRIER	CARRIER
164	CRUISERS	CRUISERS
165	DESTROYERS	DESTROYERS
166	MINESWEEPERS	MINESWEEPERS
167	FRIGATES	FRIGATES
168	CORVETTES	CORVETTES
169	MISSLE	MISSLE_
170	TORPEDO	TORPEDO_
171	BOATS	BOATS
172	LANDING	LANDING_
173	SIXTEEN	16
174	INTELLIGENCE	INTELLIGENCE_
175	SHIPS	SHIPS
176	SEVENTEEN	17
177	EIGHTEEN	18
178	KIEV CLASS	KIEV CLASS_
179	MOSKVA CLASS	MOSKVA CLASS_
180	SSN	SSN
181	DELTA CLASS	DELTA CLASS_
182	DELTA2 CLASS	DELTA II CLASS_
183	HOTEL2 CLASS	HOTEL II CLASS_
184	HOTEL3 CLASS	HOTEL III CLASS_
185	ASU57	ASU-57_
186	VICTOR CLASS	VICTOR CLASS_

187	YANKEE CLASS	YANKEE CLASS_
188	GOLF1 CLASS	GOLF I CLASS
189	GOLF2 CLASS	GOLF II CLASS_
190	ZULU4 CLASS	ZULU IV CLASS
191	KRESTA1 CLAS	KRESTA I CLASS_
192	KRESTA2 CLAS	KRESTA II CLASS_
193	MIRKA1 CLASS	MIRKA I CLASS_
194	MIRKA2 CLASS	MIRKA II CLASS_
195	PETYA1 CLASS	PETYA I CLASS_
196	PETYA2 CLASS	PETYA II CLASS_
197	JULIET CLASS	JULIET CLASS_
198	LOWER RIGHT	LOWER RIGHT
199	122 MILIMETR	122-MM_
200	FOXTROT CLAS	FOXTROT CLASS_
201	ROMEO CLASS	ROMEO CLASS_
202	SSG	SSG
203	BRAVO CLASS	BRAVO CLASS_
204	ECHO1 CLASS	ECHO I CLASS_
205	ECHO2 CLASS	ECHO II CLASS_
206	152 MILIMETR	152-MM_
207	TANGO CLASS	TANGO CLASS_
208	WHISKEY CLAS	WHISKEY CLASS_
209	CHARLIE1 CLS	CHARLIE I CLASS_
210	CHARLIE2 CLS	CHARLIE II CLASS
211	KARA CLASS	KARA CLASS_
212	SVERDLOV CLS	SVERDLOV CLASS_
213	KYNDA CLASS	KYNDA CLASS_
214	KRIVAK CLASS	KRIVAK CLASS_
215	KASHIN CLASS	KASHIN CLASS_
216	240 MILIMETR	240-MM_
217	KANIN CLASS	KANIN CLASS_
218	INTERCEPTORS	INTERCEPTORS
219	KOTLIN CLASS	KOTLIN CLASS_
220	KOTLN SAM CL	KOTLIN-SAM CLASS
221	SKORY CLASS	SKORY CLASS_
222	RIGA CLASS	RIGA CLASS_
223	GRISHA CLASS	GRISHA CLASS_
224	NANUCHKA CLS	NANUCHKA CLASS_
225	POTI CLASS	POTI CLASS_
226	OSA1 CLASS	OSA I CLASS_
227	OSA2 CLASS	OSA II CLASS_
228	KOMAR CLASS	KOMAR CLASS_
229	STENKA CLASS	STENKA CLASS_
230	NINETEEN	19
231	TWENTY	20
232	SHERSHEN CLS	SHERSHEN CLASS_
233	TWENTY-ONE	21
234	NATYA CLASS	NATYA CLASS_
235	YURKA CLASS	YURKA CLASS_
236	ALLIGATOR CL	ALLIGATOR CLASS_
237	POLNOCNY CLS	POLNOCNY CLASS_

238	TWENTY-TWO	22
239	PRIMORYE CLS	PRIMORYE CLASS_
240	TWENTY-THREE	23
241	TWENTY-FOUR	24
242	SS16	SS-16_
243	SS20	SS-20_
244	SS14 SCPGOAT	SS-14 SCAPEGOAT_
245	SS15 SCROOGE	SS-15 SCROOGE_
246	ICBM	ICBM
247	IRBM	IRBM
248	MOBILE	MOBILE_
249	M240	M-240_
250	MORTARS	MORTARS
251	ASSAULT GUNS	ASSAULT GUNS
252	ROCKET LCHRS	ROCKET LAUNCHERS
253	AIRCRAFT	AIRCRAFT
254	TWENTY-FIVE	25

APPENDIX B

SCENARIO CARDS

TYPING CARDS -> > > > > > > > FIRST TWELVE

INSTALLATION 0613-T11214

** 4 CONFIRMED BMP-76PB APC

7 CONFIRMED BRDM APC **

3 CONFIRMED AT-3 SAGGER ATGW **

** 4 PROBABLE ZSU-23/4 AA GUNS

40 CONFIRMED T-54/55 MEDIUM TANKS **

**
4 PROBABLE SA-9 GASKIN LAUNCHERS

**
6 PROBABLE ZU-23/2 AA GUNS

INSTALLATION 0115-T12314
** 5 CONFIRMED M-4 BISON BOMBERS

** 1 POSSIBLE TU-20 BEAR RECONNAISSANCE AIRCRAFT

12 CONFIRMED TU-20 BEAR BOMBERS **
** 1 CONFIRMED TU-126 MOSS AWACS

**
2 CONFIRMED BE-12 MAIL RECONNAISSANCE AIRCRAFT

7 CONFIRMED IL-28 BEAGLE BOMBERS **
17 CONFIRMED TU-16 BADGER BOMBERS **

** 3 PROBABLE TU-16 BADGER RECONNAISSANCE AIRCRAFT

INSTALLATION 0128-T13213 **

2 CONFIRMED KRESTA II CLASS CRUISERS
3 CONFIRMED KRESTA I CLASS CRUISERS **

** 1 POSSIBLE TANGO CLASS SS

** 12 CONFIRMED WHISKEY CLASS SS

2 PROBABLE CHARLIE II CLASS SSGN **

1 CONFIRMED CHARLIE I CLASS SSGN
**

INSTALLATION 0298-T14218
**

50 CONFIRMED ASU-85 AIRBORNE ASSAULT GUNS

27 CONFIRMED ASU-57 AIRBORNE ASSAULT GUNS
**

** 20 POSSIBLE M-240 HEAVY MORTARS

62 PROBABLE 122-MM D-30 FIELD HOWITZERS **

48 CONFIRMED 240-MM BM-24 ROCKET LAUNCHERS

**

INSTALLATION Ø827-T21253
6 CONFIRMED FOXTROT CLASS SS **
**
12 CONFIRMED JULIET CLASS SSG
** 2 PROBABLE DELTA II CLASS SSBN

3 PROBABLE DELTA CLASS SSBN
**

4 CONFIRMED GOLF II CLASS SSBN **

**
5 CONFIRMED POTI CLASS CORVETTES

** 2 POSSIBLE YANKEE CLASS SSBN

7 PROBABLE ROMEO CLASS SS **

INSTALLATION Ø4Ø5-T22217
**
4Ø CONFIRMED T-1Ø HEAVY TANKS

** 57 CONFIRMED T-34/85 MEDIUM TANKS
** 43 CONFIRMED T-54/55 MEDIUM TANKS

3 CONFIRMED PT-76 LIGHT AMPHIBEOUS TANKS
**
** 8 CONFIRMED BTR-152 APC

**
6 CONFIRMED BRDM RECONNAISSANCE APC

INSTALLATION 0352-T23224 **

11 CONFIRMED TU-22 BLINDER BOMBERS /

20 CONFIRMED TU-26 BACKFIRE BOMBERS **

5 PROBABLE IL-28 BEAGLE BOMBERS **

** 2 CONFIRMED IL-76 CANDID TRANSPORTS

**

15 CONFIRMED AN-12 CUB TRANSPORTS

**

7 CONFIRMED MI-8 HIP HELICOPTERS

INSTALLATION 0247-T24283

** 5 PROBABLE KOMAR CLASS MISSLE BOATS

**

17 CONFIRMED OSA I CLASS MISSLE BOATS

5 CONFIRMED OSA II CLASS MISSLE BOATS

**

** 7 CONFIRMED STENKA CLASS TORPEDO BOATS

**

11 POSSIBLE NANUCHKA CLASS TORPEDO BOATS

6 POSSIBLE GRISHA CLASS CORVETTES **

2 PROBABLE SHERSHEN CLASS TORPEDO BOATS**

INSTALLATION Ø243-T31278
**
12 CONFIRMED MIG-27 FLOGGER STRIKE/ATTACK AIRCRAFT
16 CONFIRMED SU-19 FENCER STRIKE/ATTACK AIRCRAFT **

2 POSSIBLE MIG-25R FOXBAT RECONNAISSANCE AIRCRAFT **

** 1 CONFIRMED IL-38 MAY ASW AIRCRAFT
**
3 CONFIRMED AN-8 CAMP TRANSPORTS

5 CONFIRMED AN-26 CURL TRANSPORTS
**

INSTALLATION Ø657-T32179 **
/ **
2 CONFIRMED HOTEL II CLASS SSBN /
1 CONFIRMED HOTEL III CLASS SSBN

**
1 PROBABLE GOLF I CLASS SSB
**
1 PROBABLE MIRKA I CLASS LIGHT FRIGATE

**
1 POSSIBLE ZULU IV CLASS SS

```
|---------------------|---------------------|
| INSTALLATION 2410-T33252                  |
| ** 4 CONFIRMED 100-MM M-49 AA GUNS        |
| 4 CONFIRMED ZSU-57/2 AA GUNS ---**        |
| 6 CONFIRMED 85-MM M-44 AA GUNS            |
|                     |          **         |
|      **             |                     |
|      /              |                     |
| 8 CONFIRMED FROG-4 SSM MOBILE LAUNCHERS   |
|                     |                     |
|---------------------|---------------------|
|                     |                     |
|                   **|                     |
| 6 PROBABLE AT-1 SNAPPER ATGW              |
|                     |                     |
|                  ** |                     |
| 4 CONFIRMED 122-MM D-74 FIELD GUNS        |
|                     |                     |
|                     |  **                 |
| 21 CONFIRMED 85-MM D-44 ANTI-TANK GUNS    |
----------------------|---------------------|


|---------------------|---------------------|
| INSTALLATION 0173-T34246    **         **  |
| 1 CONFIRMED TU-126 MOSS AWACS         /   |
| 1 CONFIRMED TU-16 BADGER RECONNAISSANCE   |
|   AIRCRAFT          |                     |
| 16 CONFIRMED AN-22 COCK TRANSPORTS        |
|                  ** |                     |
|                     |                     |
|                     |                     |
|---------------------|---------------------|
| 18 CONFIRMED TU-20 BEAR BOMBERS           |
|                /    |                     |
|             **      |                     |
|                     |                     |
| 12 CONFIRMED TU-22 BLINDER BOMBERS **     |
|                     |                     |
|                     |                     |
| 2 CONFIRMED TU-20 BEAR RECONNAISSANCE     |
|   AIRCRAFT          |  **                 |
----------------------|---------------------|
```

VOICE- UNBUFFERED CARDS -> > > NEXT TWELVE

```
|----------------------|---------------------|
| INSTALLATION 0156-V11250      **           |
|                      |       /             |
|9 PROBABLE YAK-28P_FIREBAR FIGHTER-BOMBERS  |
|                      |                     |
|** 12 CONFIRMED SU-15_FLAGON INTERCEPTORS   |
|                      |                     |
|20 CONFIRMED TU-28P_FIDDLER INTERCEPTORS    |
|                      |                **   |
|                      |**                   |
| 13 PROBABLE MIG-25_FOXBAT INTERCEPTORS     |
|                      |                     |
|                      |                     |
|     11 POSSIBLE SU-9_FISHPOT FIGHTERS **   |
|                      |                     |
|                      |                     |
| 15 PROBABLE MIG-21_FISHBED FIGHTERS**      |
-----------------------|---------------------|
```

```
|----------------------|---------------------|
| INSTALLATION 0357-V12252                   |
|                      |         **          |
|          1 CONFIRMED MOSKVA_CLASS CARRIER  |
|                      |                     |
|             **       |                     |
| 1 CONFIRMED KIEV_CLASS CARRIER             |
|                      |                     |
|     ** 2 PROBABLE KARA_CLASS CRUISERS      |
|----------------------|---------------------|
|          2 POSSIBLE VICTOR_CLASS SSN   **  |
|                      |                     |
|   ** 3 CONFIRMED KASHIN_CLASS DESTROYERS   |
|                      |                     |
| ** 4 CONFIRMED KRIVAK_CLASS FRIGATES       |
|                      |                     |
|                    **|                     |
| 8 CONFIRMED MIRKA_II_CLASS LIGHT FRIGATES  |
|                      |                     |
-----------------------|---------------------|
```

```
INSTALLATION Ø188-V13259                    **
6 PROBABLE 57-MM S-6Ø MEDIUM AA_GUNS

 ** 4 CONFIRMED SA-8_GECKO LAUNCHERS


      3 CONFIRMED SA-4_GANEF LAUNCHERS **

                   **
      4 CONFIRMED SA-6_GAINFUL LAUNCHERS

 3 CONFIRMED SS-12_SCALEBOARD MOBILE SSM
                                           **
     5 CONFIRMED FROG-3 MOBILE SSM **


 ** 4 CONFIRMED SA-9_GASKIN LAUNCHERS
```

```
INSTALLATION Ø199-V14197
                          **
  16 CONFIRMED MI-4_HOUND HELICOPTERS

                     **
 11 CONFIRMED MI-12_HOMER HELICOPTERS

 ** 5 PROBABLE MI-6_HOOK HELICOPTERS

                       **
    21 CONFIRMED MI-1Ø_HARKE HELICOPTERS


                 **
      19 PROBABLE MI-24_HIND HELICOPTERS
```

INSTALLATION 0208-V21221

**

1 CONFIRMED SS-16 MOBILE ICBM

** 1 POSSIBLE SS-15_SCROOGE MOBILE IRBM
** 1 CONFIRMED SS-14_SCAPEGOAT MOBILE IRBM
2 PROBABLE SS-20 MOBILE IRBM **

** 1 CONFIRMED FROG-7 SSM
** 3 CONFIRMED SCUD_A SSM

**

1 POSSIBLE SCUD_B SSM

INSTALLATION 0195-V22231

10 CONFIRMED KA-25_HORMONE HELICOPTERS
**

**

11 CONFIRMED MI-8_HIP HELICOPTERS

** 4 CONFIRMED KA-15_HEN HELICOPTERS

** 6 CONFIRMED KA-18_HOG HELICOPTERS

**

20 CONFIRMED IL-12_COACH TRANSPORTS

22 CONFIRMED IL-14_CRATE TRANSPORTS **

INSTALLATION 0327-V23249
** 2 PROBABLE PRIMORYE_CLASS INTELLIGENCE SHIPS
**
3 CONFIRMED POLNOCNY_CLASS LANDING SHIPS
2 CONFIRMED ALLIGATOR_CLASS LANDING SHIPS
**

**
3 CONFIRMED YURKA_CLASS MINESWEEPERS

**
2 POSSIBLE NATYA_CLASS MINESWEEPERS

4 PROBABLE PETYA_I_CLASS FRIGATES
**

INSTALLATION 0187-V24277
** 60 CONFIRMED BTR-60PK AMPHIBEOUS APC
** 25 CONFIRMED T-62 MEDIUM TANKS

23 CONFIRMED 85-MM D-44 ANTI-TANK_GUNS **

**
18 PROBABLE BM-21 ROCKET_LAUNCHERS

**22 CONFIRMED 122-MM D-30 FIELD_HOWITZERS

**
19 CONFIRMED M-1955 FIELD_HOWITZERS

17 CONFIRMED M-1976 AIRBORNE **
ASSAULT_GUNS

INSTALLATION 0528-V31176

** 11 CONFIRMED PETYA_II_CLASS FRIGATES

** 2 PROBABLE BRAVO_CLASS SS

**
3 CONFIRMED ECHO_I_CLASS SSGN

**
12 CONFIRMED ECHO_II_CLASS SSGN

**
5 CONFIRMED RIGA_CLASS FRIGATES

INSTALLATION 0410-V32237 **
22 CONFIRMED BTR-50PK AMPHIBEOUS APC

40 CONFIRMED T-72 HEAVY TANKS -- **
18 PROBABLE SU-100 ASSAULT_GUNS
**

**25 CONFIRMED 152-MM D-20 FIELD_HOWITZERS

**
24 CONFIRMED 100-MM M-1955 FIELD_GUNS

**
13 PROBABLE M-1976 AIRBORNE ASSAULT_GUNS

```
|---------------------|---------------------|
| INSTALLATION Ø276-V33264                  |
|  15 CONFIRMED MIG-21_FISHBED FIGHTERS     |
|                   **|                     |
|                     |                   **|
|12 CONFIRMED MIG-19_FARMER FIGHTER-BOMBERS|
|                     |                     |
|** 11 PROBABLE MIG-23_FLOGGER FIGHTERS     |
|---------------------|-------------------**|
| 17 CONFIRMED MIG-27_FLOGGER STRIKE/ATTACK|
|    AIRCRAFT         |                     |
|     **              |                     |
| 21 CONFIRMED MIG-25_FOXBAT INTERCEPTORS   |
|                **   |                     |
| 3 POSSIBLE TU-28P_FIDDLER INTERCEPTORS    |
----------------------|---------------------|


|---------------------|---------------------|
| INSTALLATION Ø362-V34273                  |
|                     |                     |
| ** 2 PROBABLE SKORY_CLASS DESTROYERS      |
|                     |                     |
|  ** 3 CONFIRMED KOTLIN_CLASS DESTROYERS   |
|                     |                     |
|  2 CONFIRMED KYNDA_CLASS CRUISERS **      |
|    5 CONFIRMED KANIN_CLASS DESTROYERS     |
|  **                 |                     |
|-- -----------------|---------------------|
| 2 CONFIRMED SVERDLOV_CLASS DESTROYERS     |
|  **                 |                     |
|               **    |                     |
|   2 PROBABLE SHERSHEN_CLASS TORPEDO BOATS|
|                     |                     |
|  4 CONFIRMED KOTLIN_SAM_CLASS DESTROYERS  |
|                     |              **     |
----------------------|---------------------|
```

BUFFERED-VOICE CARDS -> > > > > NEXT TWELVE

```
|----------------------|----------------------|
| INSTALLATION 0613-V51214                    |
|                      |                      |
|** 4 CONFIRMED BMP-76PB APC                  |
|                  7 CONFIRMED BRDM APC **    |
|                      |                      |
|3 CONFIRMED AT-3_SAGGER ATGW   **            |
|                      |                      |
|            ** 4 PROBABLE ZSU-23/4 AA_GUNS   |
|----------------------|----------------------|
| 40 CONFIRMED T-54/55 MEDIUM TANKS   **      |
|                      |                      |
|                      |                 **   |
|           4 PROBABLE SA-9_GASKIN LAUNCHERS   |
|                      |                      |
|                      |        **            |
|           6 PROBABLE ZU-23/2 AA_GUNS         |
-----------------------|----------------------|
```

```
|----------------------|----------------------|
| INSTALLATION 0115-V52314                    |
| ** 5 CONFIRMED M-4_BISON BOMBERS            |
|                      |                      |
| ** 1 POSSIBLE TU-20_BEAR RECONNAISSANCE     |
|    AIRCRAFT          |                      |
|                      |                      |
| 12 CONFIRMED TU-20_BEAR BOMBERS **          |
|          ** 1 CONFIRMED TU-126_MOSS AWACS   |
|                      |                      |
|-**-------------------|----------------------|
|2 CONFIRMED BE-12_MAIL RECONNAISSANCE        |
|AIRCRAFT              |                      |
|                      |                      |
|     7 CONFIRMED IL-28_BEAGLE BOMBERS **     |
| 17 CONFIRMED TU-16_BADGER BOMBERS   **      |
|                      |                      |
| ** 3 PROBABLE TU-16_BADGER RECONNAISSANCE   |
|    AIRCRAFT                                 |
-----------------------|----------------------|
```

```
INSTALLATION 0128-V53213                  **
                                         /
2 CONFIRMED KRESTA_II_CLASS CRUISERS
  3 CONFIRMED KRESTA_I_CLASS CRUISERS **

      ** 1 POSSIBLE TANGO_CLASS SS


** 12 CONFIRMED WHISKEY_CLASS SS

2 PROBABLE CHARLIE_II_CLASS SSGN  **



   1 CONFIRMED CHARLIE_I_CLASS SSGN
                **
```

```
INSTALLATION 0298-V54218
                                      **
50 CONFIRMED ASU-85 AIRBORNE ASSAULT_GUNS

27 CONFIRMED ASU-57 AIRBORNE ASSAULT_GUNS
**



 ** 20 POSSIBLE M-240 HEAVY MORTARS

62 PROBABLE 122-MM D-30 FIELD_HOWITZERS **


48 CONFIRMED 240-MM BM-24 ROCKET_LAUNCHERS

              **
```

```
INSTALLATION 0827-V61253
6 CONFIRMED FOXTROT_CLASS SS **
                                          **
     12 CONFIRMED JULIET_CLASS SSG
** 2 PROBABLE DELTA_II_CLASS SSBN

3 PROBABLE DELTA_CLASS SSBN
           **

   4 CONFIRMED GOLF_II_CLASS SSBN **

             **
    5 CONFIRMED POTI_CLASS CORVETTES


** 2 POSSIBLE YANKEE_CLASS SSBN

     7 PROBABLE ROMEO_CLASS SS   **
```

```
INSTALLATION 0405-V62217
                          **
40 CONFIRMED T-10 HEAVY TANKS

 **  57 CONFIRMED T-34/85 MEDIUM TANKS
**  43 CONFIRMED T-54/55 MEDIUM TANKS



3 CONFIRMED PT-76 LIGHT AMPHIBEOUS TANKS
 **
   ** 8 CONFIRMED BTR-152 APC

                            **
 6 CONFIRMED BRDM RECONNAISSANCE APC
```

```
INSTALLATION Ø352-V63224                        **
                                               /
  11 CONFIRMED TU-22_BLINDER BOMBERS

 2Ø CONFIRMED TU-26_BACKFIRE BOMBERS **
 5 PROBABLE IL-28_BEAGLE BOMBERS-**

  ** 2 CONFIRMED IL-76_CANDID TRANSPORTS
                          **
15 CONFIRMED AN-12_CUB TRANSPORTS
                         **
 7 CONFIRMED MI-8_HIP HELICOPTERS
```

```
INSTALLATION Ø247-V64283

** 5 PROBABLE KOMAR_CLASS MISSLE BOATS
                                      **
17 CONFIRMED OSA_I_CLASS MISSLE BOATS

 5 CONFIRMED OSA_II_CLASS MISSLE BOATS
**

** 7 CONFIRMED STENKA_CLASS TORPEDO BOATS
   **
11 POSSIBLE NANUCHKA_CLASS TORPEDO BOATS

  6 POSSIBLE GRISHA_CLASS CORVETTES **
2 PROBABLE SHERSHEN_CLASS TORPEDO BOATS**
```

```
INSTALLATION 0243-V71278
**
12 CONFIRMED MIG-27_FLOGGER STRIKE/ATTACK
   AIRCRAFT
16 CONFIRMED SU-19_FENCER STRIKE/ATTACK
   AIRCRAFT                    **

2 POSSIBLE MIG-25R_FOXBAT RECONNAISSANCE
___AIRCRAFT__**_____

   ** 1 CONFIRMED IL-38_MAY ASW AIRCRAFT
**
  3 CONFIRMED AN-8_CAMP TRANSPORTS


5 CONFIRMED AN-26_CURL TRANSPORTS
                                     **
```

```
INSTALLATION 0657-V72179          **
                               /    **
2 CONFIRMED HOTEL_II_CLASS SSBN   /
1 CONFIRMED HOTEL_III_CLASS SSBN


                 **
1 PROBABLE GOLF_I_CLASS SSB
                   **
1 PROBABLE MIRKA_I_CLASS LIGHT FRIGATE

                    **
1 POSSIBLE ZULU_IV CLASS SS
```

```
|---------------------|---------------------|
| INSTALLATION 0410-V73252                  |
| ** 4 CONFIRMED 100-MM M-49 AA_GUNS        |
| 4 CONFIRMED ZSU-57/2 AA_GUNS ---**        |
| 6 CONFIRMED 85-MM M-44 AA_GUNS --**       |
|                     |                     |
|      **             |                     |
|      /              |                     |
| 8 CONFIRMED FROG-4 SSM MOBILE LAUNCHERS   |
|---------------------|---------------------|
|                   **|                     |
| 6 PROBABLE AT-1_SNAPPER ATGW              |
|                     |                     |
|                  ** |                     |
| 4 CONFIRMED 122-MM D-74 FIELD_GUNS        |
|                     |                     |
|                     |   **                |
| 21 CONFIRMED 85-MM D-44 ANTI-TANK_GUNS    |
----------------------|---------------------|


|---------------------|---------------------|
| INSTALLATION 0173-V74246    **         ** |
| 1 CONFIRMED TU-126_MOSS AWACS          /  |
| 1 CONFIRMED TU-16_BADGER RECONNAISSANCE   |
|   AIRCRAFT          |                     |
| 16 CONFIRMED AN-22_COCK TRANSPORTS        |
|                  ** |                     |
|                     |                     |
|                     |                     |
|                     |                     |
|---------------------|---------------------|
| 18 CONFIRMED TU-20_BEAR BOMBERS           |
|               /     |                     |
|             **      |                     |
|                     |                     |
| 12 CONFIRMED TU-22_BLINDER BOMBERS **     |
|                     |                     |
|                     |                     |
| 2 CONFIRMED TU-20_BEAR RECONNAISSANCE     |
|   AIRCRAFT          |   **                |
----------------------|---------------------|
```

APPENDIX C

T600 TRAINING INSTRUCTIONS

For this experiment a 254 word vocabulary will be used with the Threshold 600 (T600) voice recognition system. You will be required to speak each utterance ten times to train the T600 to recognize your voice. Two sessions of approximately 90 minutes will be required to complete the training prior to experimentation.

Please observe the following guidelines during training and operation of the T600, as they will improve performance and reduce the time required for retraining.

a. Use variety. Say the repetitions with the variety of intonation, emphasis, and volume you would expect to use in normal speech.

d. Speak crisply without pausing. Be natural and relaxed. Don't exaggerate or overemphasize; for example when saying the word "five", don't say "FI-I-VEH", thereby overemphasizing the end of the word in an unnatural way.

b. Do the repetitions in groups to avoid breath noise and help you count the reps. For example to train the word "zero" group the zeros as follows:

    ØØØ-ØØØ-ØØØ-Ø

or

    ØØØ-ØØØ-ØØØØ

rather than -

    ØØØØØØØØØØ

or

    Ø-Ø-Ø-Ø-Ø-Ø-Ø-Ø-Ø-Ø

c. Adjust the microphone carefully, as demonstrated (see the picture).

e. Leave a distinct pause between words. You must wait for the green READY light to come on before saying the next utterance.

f. Use the proper volume. Watch the meter; the needle should be in the green area or just slightly in the red on the peak parts of the word. Words trained in the lower white or upper red will give poorer results.

Once you are comfortable with training the T600, I will ask you to operate the keyboard for the remainder of the training. I will remain nearby to provide assistance as required. Be sure to ask for help if you have any questions. Take breaks as you need them; a convenient place to break is every few pages.

******************** Operating the T600 ********************

To train a word -	YOU TYPE	T600 RESPONSE
	CTRL-U	WD#:
	<word number>	<word prompt>
	.e.g. 0	ZERO

Now you say the word or phrase 10 times. Once the current phrase disappears you are ready to go onto the next word of the vocabulary. Again you type CTRL-U and continue as before.

APPENDIX D

TYPING TEST

THE SOVIET NAVAL AIR FORCE

FOR THE FIRST TIME IN ITS HISTORY, THE SOVIET NAVAL AIR FORCE WILL BE PUTTING TO SEA WITH ITS OWN AIRCRAFT EMBARKED ON THE FIRST OF THE NEW SOVIET AIRCRAFT CARRIERS, THE KIEV, WHICH HAD ALREADY BEGUN ITS WORKING-UP TRIALS IN THE AUTUMN OF 1974. DISPLACING SOME 36,000 TONS WITH AN OVERALL LENGTH SLIGHTLY IN EXCESS OF 900 FEET, THE KIEV IS PRESUMED TO EMBARK 40-50 AIRCRAFT IN ALL, COMPRISING A MIX OF HELICOPTERS AND FIXED-WING V/STOL AIRCRAFT (THE KIEV SHOWS NO SIGNS OF ARRESTER CABLES OR LAUNCH CATAPULTS). THE SUGGESTED VERSION OF THE STRIKE AND RECONNAISSANCE FIGHTER TO BE EMBARKED ON THE KIEV IS THE YAK-36, A VERSION OF WHICH WAS TESTED ON THE AIRFIELDS NEAR MOSCOW AND GIVEN SEA TRIALS ON THE SOVIET HELICOPTER-CARRIER MOSKVA. THE YAK-36 UTILIZES VECTORED THRUST AND DIRECT LIFT IN COMBINATION. SUCH AN AIR COMPLEMENT MIGHT BE BROKEN DOWN INTO 30 KA-25 ASW HELICOPTERS AND 15-20 V/STOL FIXED-WING AIRCRAFT. HOW MANY OF THESE CARRIERS WILL BE PRODUCED ?

AT LEAST TWO OF THESE KIEV-CLASS AIRCRAFT CARRIERS ARE DUE TO ENTER SERVICE, WITH THE POSSIBILITY OF THE SOVIET NAVY PRODUCING A WHOLE CLASS OF SOME 6-8 SHIPS, THEREBY

FACILITATING CONTINUOUS DEPLOYMENT OF ONE VESSEL IN BOTH THE MEDITERRANEAN AND THE INDIAN OCEAN. THE HELICOPTER COMPLEMENT PROVIDES INTENSIVE ASW CAPABILITY INTO DISTANT SEA AREAS (FOR DEFENSIVE AND OFFENSIVE PURPOSES), AS WELL AS FURNISHING AIRBORNE TARGET GUIDANCE FOR SURFACE-TO SURFACE ANTISHIP MISSLES. THE V/STOL AIRCRAFT, WHILE PROVIDING A STRIKE CAPABILITY, MUST OBVIOUSLY INCREASE THE RECONNAISSANCE COVERAGE OF THE SOVIET NAVAL AIR ARM IN AREAS WHICH ARE BEYOND THE RANGE OF EXISTING LAND-BASED AIRCRAFT. MEANWHILE, THE ARMAMENT OF THE KIEV-CLASS SHIPS IS ITSELF SIGNIFICANT. IT CONSISTS OF A TWIN LAUNCHER FOR ASW MISSLES, TWO 12-BARRELL MSU AS ROCKET LAUNCHERS, TWO SA-N-3 SAM TWIN LAUNCHERS, A NUMBER OF RETRACTABLE SA-N-4 SAM LAUNCHERS, MULTIPLE 57-MM AAA MOUNTS AND SMALLER WEAPONS FOR CLOSE-IN PROTECTION AGAINST MISSLES AND OTHER GUIDED WEAPONS.

APPENDIX E

PRE/POST SUBJECTIVE QUESTIONNAIRE

Subjective Questionnaire Name:____________________

INSTRUCTIONS: Express your feelings regarding typed data entry and voice data entry. CIRCLE THE NUMBER which BEST DESCRIBES your opinion for each question.

1. Which data entry mode do you think is the easiest to use to enter character strings and commands?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

2. Which data entry mode do you think is the fastest mode for entering character strings and commands?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

3. Which data entry mode is the most accurate for entering character strings and commands?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

4. Which data entry mode provides the most flexibility, in general, for interaction with a computer?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

5. Which data entry mode would you prefer to operate for several hours, if required?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

6. Which data entry mode would you prefer to operate as a more sporadic user of a computer system?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

7. Which data entry mode promotes the most relaxed operation?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

8. Which data entry mode would be the most advantageous to use to update an on-line data base of intelligence information?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

9. Which data entry mode provides the best man-machine interface in a time-critical, high-pressure work environment?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

10. Which data entry mode do you think is the easiest to learn?

Typed Data Entry			Neutral			Voice Data Entry
<=	<=	<=	*	=>	=>	=>
1	2	3	4	5	6	7

APPENDIX F

SUBJECT DATA SHEET

Subject Data Sheet Date:______________

Name:____ Age:___

Service:___________________ Rank/Grade:___________________

Job/Specialty Description (last job / next job) __________

____

Prior to this experiment what has been your experience with voice data entry systems ? Check one or more.

_____a. I have used a voice data entry system.

_____b. I have seen a voice data entry system demonstrated.

_____c. I have studied voice data entry systems (class, report, thesis, etc.)

_____d. I have no experience with voice data entry systems.

If you checked a. above, circle the term that best describes your experience and skill with voice data entry.

Experience -		Skill-	
	Considerable		High
	Moderate		Average
	Minimal		Novice

Explain:____

____

____

If you checked c. above, please briefly state the extent of your studies.

____

____

APPENDIX G

INSTRUCTIONS BRIEFED TO SUBJECTS

TYPING MODE

1. During this portion of the experiment you will view 12 cards and use the ADM terminal to write a report on each card similar to the one you saw in the sample (or other portion of the experiment). I will stop you after every four cards. This will give you a break and allow me to collect some data.

2. You will be using a text editor at the ISIE host computer. The edit keys discussed during training which may be used are shown on the card at the terminal. You may edit errors only if you are on the line with the error in it, i.e. if you notice an error on the previous line, do not attempt to correct it. However, I will demonstrate how you may void the previous line if you wish to do it over.

3. Pencil and paper are provided if you want to use them to take notes as you look in the viewport.

4. Now practice on this card.

5. <critique the report>

6. You are to go as fast as you can while trying to minimize errors. Keep in mind you are writing an intelligence report which should be timely, accurate, and complete. Questions?

7. Ok, start.

8. <Trial #1>

9. Ok, stop. Rest a moment, then you will do four more.

10. Ok, start.

11. <Trial #2>

12. Ok, stop. Rest a moment, this is the last set of four you will type for the experiment.

13. Ok, start.

14. <Trial #3>

15. Stop. You deserve a break. Relax a while. You may get up and move around, get a drink, etc.

VOICE-UNBUFFERED MODE

1. During this portion of the experiment you will view 12 cards, and use the T600 in unbuffered mode to write a report for each card like the one you saw in the sample (or other part of the experiment). I will stop you after every four cards. This will save you a break and allow me to collect some data.

2. The T600 unbuffered mode allows you to send the output corresponding to an utterance immediately to the host computer. So for example, when you say "CONFIRMED," it is sent immediately to the computer, and in this case, becomes a part of the text in the text editor at the ISIE computer. You may edit your input as long as you are on the line that has the error using the edit commands you trained. A list of the edit commands you use is provided for you here, along with a list of the vocabulary as reference material.

3. If you look in the viewport at this time, you will see that the three bottom lines of the T600 display may be seen. These will provide a visual feedback of the text editor contents, and allow you to view the editing process as well as the card.

4. Now practice using the sample card provided.

5. <critique the report>

6. You are to go as fast as you can while trying to minimize errors. Keep in mind you are writing an intelligence report which should be timely, accurate, and complete. Questions?

7. Ok, start.

8. <Trial #1>

9. Ok, stop. Rest a moment, then you will do four more.

10. Ok, start.

11. <Trial #2>

12. Ok, stop. Rest a moment, this will be your last set of four to enter for the unbuffered mode part of the experiment.

13. Ok, start.

14. <Trial #3>

15. Stop. You deserve a break. Relax a while. You may get up and move around, get a drink, etc.

VOICE-BUFFERED MODE

1. During this portion of the experiment you will view 12 cards, and use the T600 in buffered mode to write a report for each card like the one you saw in the sample (or other part of the exper- iment). I will stop you after every four cards. This will give you a break and allow me to collect some data.

2. The T600 buffered mode allows you to speak a chain of phrases prior to sending them to the host computer. You may edit the last utterance in the buffer by saying "kill line" or its equivalent for your vocabulary. If you make several errors, the entire buffer may be erased with the command "kill line." Once you are ready to send the contents of the buffer, you say "go" or "carriage return," whichever you trained, and the character string will be sent to the text editor at ISIE. However, you will not be able to use the editing features of the text editor at ISIE while in the buffered mode. I will demonstrate the buffered mode for you now.

3. If you look in the viewport at this time, you will see that the three bottom lines of the T600 display may be seen. These will provide a visual feedback of the buffer contents, and allow you to view the editing process as well as the card.

4. Now practice using the sample card provided.

5. <critique the report>

6. You are to go as fast as you can while trying to minimize errors. Keep in mind you are writing an intelligence report which should be timely, accurate, and complete. Questions?

7. Ok, start.

8. <Trial #1>

9. Ok, stop. Rest a moment, then you will do four more.

10. Ok, start.

11. <Trial #2>

12. Ok, stop. Rest a moment, this will be your last set of four to enter for the buffered mode part of the experiment.

13. Ok, start.

14. <Trial #3.

15. Stop. You deserve a break. Relax a while. You may get up and move around, get a drink, etc.

APPENDIX H

VOCABULARY WORDS MISRECOGNIZED OR REJECTED

NOTE: THE FOLLOWING LIST IS IN ASCENDING COLLATING SEQUENCE BY UTTERANCE AND MISRECOGNITON. THE MISRECOGNITIONS HAVE THE FOLLOWING FORMAT:

A (B) X N

WHERE

A = UTTERANCE ASSOCIATED WITH T600 MISRECOGNITION
B = SPECIFIC T600 OUTPUT, IF DIFFERENT THAN A ABOVE; E.G."(2)" MEANS THAT A NUMERAL WAS OUTPUT RATHER THAN THE WORD "TWO"
N = NUMBER OF OCCURENCES

************* * UTTERANCE * *************	********************** * MISRECOGNITION(S) * **********************
122-MM	100-MM X 2
122-MM	152-MM X 3
152-MM	122-MM X 8
85-MM	57-MM
AA GUNS	AN-8 CAMP X 6
AA GUNS	ANTI-TANK GUNS X 3
AA GUNS	YAK-28P FIREBAR
AIRCRAFT	ANTI-TANK GUNS
AIRCRAFT	CARRIER
AIRCRAFT	TU-26 BACKFIRE
AMPHIBIOUS	FRIGATES X 3
AN-8 CAMP	AA GUNS
ANTI-TANK GUNS	AMPHIBIOUS
ANTI-TANK GUNS	AN-8 CAMP X 4
ANTI-TANK GUNS	BEEP* X 6
ASSAULT GUNS	BEEP* X 16
ASSAULT GUNS	MISSILE
ASU-57	AT-3 SAGGER
AT-1 SNAPPER	BEEP*
AT-3 SAGGER	APC
BM-21	M-44
BM-24	BM-21
BMP-76PB	BTR-60PK
BOATS	BEEP*

* UTTERANCE *	* MISRECOGNITION(S) *
BOMBERS	ALPHA (A)
BOMBERS	BEEP* X 7
BOMBERS	IL-14 CRATE X 2
BOMBERS	LAUNCHERS
BRAVO	FRIGATE
BRAVO CLASS	GOLF I CLASS
BRAVO CLASS	KOMAR CLASS X 2
BRAVO CLASS	KOTLIN CLASS X 2
BRDM	TORPEDO
BRDM	YANKEE
BTR-152	NINETEEN (19)
BTR-5ØPK	BTR-6ØPK X 4
BTR-5ØPK	D-2Ø
BTR-6ØPK	BTR-5ØPK X 3
CARRIAGE RETURN	AN-8 CAMP X 4
CARRIAGE RETURN	BEEP* X 2
CARRIAGE RETURN	BRDM
CARRIAGE RETURN	CARRIER X 11
CARRIAGE RETURN	FRIGATE X 2
CARRIAGE RETURN	FRIGATES
CARRIAGE RETURN	HEAVY X 3
CARRIAGE RETURN	SSN
CARRIAGE RETURN	VICTOR (V)
CARRIAGE RETURN	XRAY (X)
CARRIAGE RETURN	YAK-28P FIREBAR X 2
CARRIAGE RETURN	ZSU-23/4
CHARLIE I CLASS	FOXTROT CLASS
CHARLIE I CLASS	KOTLIN CLASS
CHARLIE I CLASS	MIRKA I CLASS X 2
CONFIRMED	AIRBORNE
CONFIRMED	BEEP* X 148
CONFIRMED	BOMBERS
CONFIRMED	BRAVO (B) X 4
CONFIRMED	BRDM
CONFIRMED	ELEVEN (11) X 6
CONFIRMED	FIVE (5) X 7
CONFIRMED	FOUR (4)
CONFIRMED	HEAVY X 4
CONFIRMED	KOTLIN CLASS
CONFIRMED	LANDING
CONFIRMED	LIMA (L) X 5
CONFIRMED	MI-4 HOUND X 5
CONFIRMED	MIKE (M) X 2
CONFIRMED	NINE (9)
CONFIRMED	NOVEMBER (N) X 2
CONFIRMED	SA-8 GECKO
CONFIRMED	SEVEN (7) X 2

************* * UTTERANCE * *************	*********************** * MISRECOGNITION(S) * ***********************
CONFIRMED	TEN (10)
CONFIRMED	TWELVE (12) X 7
CONFIRMED	TWENTY (20)
CONFIRMED	TWENTY-FIVE (25)
CONFIRMED	TWENTY-ONE (21)
CONFIRMED	UNIFORM (U)
CONFIRMED	UPPER RIGHT
CONFIRMED	XRAY (X) X 6
CONFIRMED	ZSU-23/4
CRUISERS	TWENTY-THREE (23)
D-30	D-74
D-44	TWENTY-FOUR (24)
DASH	QUEBEC (Q)
DASH	TEN (10)
DELETE LINE	LIMA (L)
DELETE WORD	DELETE LINE (CTRL X)
DELETE WORD	TWENTY-THREE (23)
DELTA CLASS	KOTLIN CLASS X 2
DELTA II CLASS	GOLF II CLASS X 2
ECHO I CLASS	PETYA I CLASS X 2
ECHO II CLASS	DELTA II CLASS X 2
ECHO II CLASS	PETYA II CLASS
ECHO II CLASS	SHERSHEN CLASS
EIGHT	AA GUNS X 4
EIGHT	AMPHIBIOUS
EIGHT	AN-8 CAMP X 3
EIGHT	APC
EIGHT	ASU-85
EIGHT	BEEP* X 4
EIGHT	EIGHTEEN (18) X 4
EIGHT	FIFTEEN (15)
EIGHT	FOUR (4) X 5
EIGHT	HEAVY X 8
EIGHT	KA-15 HEN X 14
EIGHT	MEDIUM
EIGHT	SA-8 GECKO
EIGHT	YANKEE (Y) X 7
ELEVEN	BEEP* X 8
ELEVEN	D-20
ELEVEN	FIVE (5) X 2
ELEVEN	FOUR (4)
ELEVEN	ONE (1) X 3
ELEVEN	UPPER LEFT
ELEVEN	UPPER RIGHT
ERASE	EIGHT (8)
FIELD GUNS	BEEP* X 2
FIELD GUNS	JULIETT X 2

************* * UTTERANCE * *************	********************** * MISRECOGNITION(S) * **********************
FIELD GUNS	T-10
FIELD HOWITZERS	BEEP* X 5
FIELD HOWITZERS	HELICOPTERS X 4
FIELD HOWITZERS	INTELLIGENCE
FIFTEEN	EIGHTEEN (18)
FIFTEEN	THIRTEEN (13) X 5
FIGHTER	FRIGATES
FIGHTER-BOMBERS	ROCKET LAUNCHERS
FIGHTER-BOMBERS	BEEP* X 3
FIGHTER-BOMBERS	TWENTY-ONE (21)
FIVE	AN-8 CAMP
FIVE	BEEP* X 2
FIVE	NINE (9) X 2
FIVE	PAPA (P) X 2
FIVE	QUEBEC (Q) X 2
FORTY	THREE (3)
FOUR	BEEP* X 33
FOUR	FROG-4
FOUR	LOWER RIGHT X 4
FOUR	MOBILE
FRIGATE	IL-38 MAY
FRIGATES	BEEP*
FRIGATES	FRIGATE
FRIGATES	SHERSHEN CLASS
FROG-3	BEEP*
FROG-3	D-20
FROG-4	PROBABLE
GO	BEEP* X 24
GO	BRAVO (B) X 2
GO	DELTA (D)
GO	ECHO (E) X 3
GO	GOLF (G)
GO	TWELVE (12)
GO	ZERO (0)
GOLF I CLASS	OSA I CLASS
GRISHA CLASS	KYNDA CLASS
GRISHA CLASS	RIGA CLASS
GRISHA CLASS	VICTOR CLASS
HEAVY	SCUD B
HELICOPTERS	BEEP* X 5
HELICOPTERS	BRAVO (B)
HELICOPTERS	FOXTROT (F)
HELICOPTERS	MI-4 HOUND
HOTEL III CLASS	HOTEL II CLASS X 3
IL-14 CRATE	MI-24 HIND
INSTALLATION	BEEP* X 3
INSTALLATION	S-60

* UTTERANCE *	* MISRECOGNITION(S) *
INTELLIGENCE	BEEP* X 6
INTERCEPTORS	BEEP* X 3
INTERCEPTORS	HELICOPTERS X 6
JULIET CLASS	YURKA CLASS
KA-18 HOG	EIGHT (8)
KANIN CLASS	CARRIER
KANIN CLASS	KASHIN CLASS X 3
KANIN CLASS	KIEV CLASS
KANIN CLASS	KYNDA CLASS
KANIN CLASS	SHERSHEN CLASS X 4
KANIN CLASS	YANKEE CLASS X 5
KARA CLASS	KANIN CLASS
KARA CLASS	KOMAR CLASS
KARA CLASS	KOTLIN CLASS X 3
KARA CLASS	STENKA CLASS
KARA CLASS	YURKA CLASS X 2
KASHIN CLASS	JULIET CLASS X 8
KASHIN CLASS	KANIN CLASS
KASHIN CLASS	KOTLIN CLASS
KASHIN CLASS	NATYA CLASS X 3
KASHIN CLASS	SHERSHEN CLASS X 2
KASHIN CLASS	YANKEE CLASS
KIEV CLASS	AIRCRAFT
KIEV CLASS	JULIET CLASS
KIEV CLASS	KANIN CLASS
KIEV CLASS	KARA CLASS
KIEV CLASS	KYNDA CLASS X 2
KIEV CLASS	SHERSHEN CLASS
KIEV CLASS	STENKA CLASS X 6
KILL LINE	CHARLIE (C) X 6
KILL LINE	DELETE (CTRL X)
KILL LINE	KANIN CLASS X 2
KILL LINE	KOTLIN CLASS
KILL LINE	M-44
KILL LINE	MI-4 HOUND
KILL WORD	BEEP* X 8
KILL WORD	FIELD HOWITZERS
KILL WORD	KILL LINE X 2
KILL WORD	SEVEN (7)
KOMAR CLASS	KARA CLASS X 2
KOMAR CLASS	MIRKA I CLASS
KOTLIN CLASS	BRAVO CLASS
KOTLIN CLASS	CHARLIE II CLASS
KOTLIN CLASS	DELTA CLASS
KOTLIN CLASS	KASHIN CLASS
KOTLIN CLASS	KOMAR CLASS X 2
KOTLIN CLASS	MOSKVA CLASS

************* * UTTERANCE * *************	************************* * MISRECOGNITION(S) * *************************
KOTLIN CLASS	POLNOCNY CLASS
KOTLIN CLASS	POTI CLASS
KOTLIN CLASS	UPPER LEFT
KRESTA I CLASS	CHARLIE I CLASS
KRESTA I CLASS	ECHO I CLASS
KRESTA I CLASS	OSA I CLASS X 4
KRESTA I CLASS	RIGA CLASS
KRESTA II CLASS	NANUCHKA CLASS
KRESTA II CLASS	OSA II CLASS
KRIVAK CLASS	KANIN CLASS
KRIVAK CLASS	KARA CLASS X 2
KRIVAK CLASS	KOTLIN CLASS
KRIVAK CLASS	KYNDA CLASS
KYNDA CLASS	KANIN CLASS X 8
KYNDA CLASS	NATYA CLASS
KYNDA CLASS	RIGA CLASS
KYNDA CLASS	STENKA CLASS X 7
LANDING	BEEP*
LAUNCHERS	MORTARS X 6
LIGHT	BEEP* X 2
LIGHT	FIVE (5)
LIGHT	LOWER RIGHT X 2
LIGHT	MIKE (M) X 4
LIGHT	ONE (1)
LIGHT	TWENTY (20) X 3
LOWER LEFT	BEEP* X 19
LOWER LEFT	BTR-50PK
LOWER LEFT	CORVETTES X 2
LOWER LEFT	KOTLIN CLASS
LOWER LEFT	LIGHT
LOWER LEFT	LOWER RIGHT X 9
LOWER LEFT	MOBILE X 3
LOWER LEFT	THREE (3)
LOWER LEFT	TWENTY-ONE (21)
LOWER LEFT	UPPER LEFT X 4
LOWER RIGHT	BEEP*
LOWER RIGHT	CONFIRMED
LOWER RIGHT	LIGHT
LOWER RIGHT	LOWER LEFT
LOWER RIGHT	ONE (1) X 3
LOWER RIGHT	SEVEN (7)
LOWER RIGHT	SEVENTEEN (17)
LOWER RIGHT	UPPER RIGHT X 8
M-1955	ASU-85
M-1955	BEEP* X 2
M-1955	SU-15 FLAGON
M-1976	PT-76

************* * UTTERANCE * *************	********************** * MISRECOGNITION(S) * **********************
M-240	BEEP*
M-4 BISON	BEEP*
M-4 BISON	CHARLIE I CLASS
M-4 BISON	MI-6 HOOK
M-44	TWENTY-FOUR (24) X 3
M-49	M-1955
M-49	TWENTY-FIVE (25)
MEDIUM	BEEP*
MI-10 HARKE	MI-24 HIND X 3
MI-10 HARKE	MI-8 HIP
MI-12 HOMER	MIG-19 FARMER
MIG-19 FARMER	RIGA CLASS
MIG-21 FISHBED	IL-14 CRATE
MIG-21 FISHBED	MIG-27 FLOGGER
MIG-23 FLOGGER	KA-25 HORMONE
MIG-25 FOXBAT	MIG-25R FOXBAT X 2
MIG-25R FOXBAT	KA-25 HORMONE
MIG-25R FOXBAT	MIG-25 FOXBAT X 3
MIRKA I CLASS	ECHO II CLASS
MIRKA I CLASS	PETYA I CLASS
MIRKA II CLASS	CHARLIE II CLASS X 2
MIRKA II CLASS	DELTA II CLASS
MIRKA II CLASS	KANIN CLASS
MIRKA II CLASS	KOTLIN CLASS X 2
MIRKA II CLASS	POLNOCNY CLASS
MISSILE	TWELVE (12)
MOBILE	BEEP* X 3
MOBILE	BRAVO X 2
MOBILE	HOTEL (H)
MOBILE	PROBABLE X 6
MORTARS	LAUNCHERS
MOSKVA CLASS	BEEP* X 2
MOSKVA CLASS	GOLF I CLASS X 3
MOSKVA CLASS	NATYA CLASS
MOSKVA CLASS	POLNOCNY CLASS X 5
NANUCHKA CLASS	KOTLIN-SAM CLASS
NANUCHKA CLASS	KYNDA CLASS
NANUCHKA CLASS	SHERSHEN CLASS
NANUCHKA CLASS	STENKA CLASS X 2
NANUCHKA CLASS	YANKEE CLASS
NANUCHKA CLASS	YURKA CLASS
NATYA CLASS	ALLIGATOR CLASS X 2
NATYA CLASS	BEEP*
NATYA CLASS	KANIN CLASS X 3
NATYA CLASS	KASHIN CLASS X 2
NATYA CLASS	KOTLIN CLASS
NATYA CLASS	KYNDA CLASS

UTTERANCE	MISRECOGNITION(S)
NATYA CLASS	POTI CLASS
NINE	BEEP* X 2
NINE	FIVE (5) X 5
NINE	LIGHT
NINE	MI-8 HIP
NINE	MIKE (M)
NINE	TWENTY (20) X 6
NINETEEN	EIGHTEEN
NINETEEN	MIKE (M)
NINETEEN	THIRTEEN (13)
ONE	BEEP* X 4
ONE	FIVE (5) X 7
ONE	FOUR (4)
ONE	FOURTEEN (14) X 2
ONE	LIGHT X 2
ONE	M-44
ONE	UPPER RIGHT
OSA I CLASS	MIRKA I CLASS
OSA II CLASS	KRESTA II CLASS X 2
PETYA I CLASS	NANUCHKA CLASS
PETYA I CLASS	YANKEE CLASS
PETYA II CLASS	ECHO II CLASS
PETYA II CLASS	HOTEL II CLASS
PETYA II CLASS	KASHIN CLASS
PETYA II CLASS	SHERSHEN CLASS
POLNOCNY CLASS	ALLIGATOR CLASS
POLNOCNY CLASS	BEEP* X 2
POLNOCNY CLASS	ECHO II CLASS
POLNOCNY CLASS	HOTEL II CLASS
POLNOCNY CLASS	HOTEL III CLASS
POLNOCNY CLASS	KOTLIN CLASS
POLNOCNY CLASS	MOSKVA CLASS
POSSIBLE	BEEP*
POTI CLASS	KANIN CLASS
POTI CLASS	KOTLIN CLASS X 3
POTI CLASS	MOSKVA CLASS X 6
POTI CLASS	ROMEO CLASS
POTI CLASS	WHISKEY CLASS X 2
PRIMORYE CLASS	ECHO I CLASS
PRIMORYE CLASS	MIRKA I CLASS
PRIMORYE CLASS	MIRKA II CLASS
PROBABLE	BEEP*
PROBABLE	BRAVO (B) X 7
PROBABLE	MOBILE X 3
PROBABLE	POSSIBLE
PROBABLE	TORPEDO
PROBALBLE	TWENTY-FOUR (24)

************* * UTTERANCE * *************	************************ * MISRECOGNITION(S) * ************************
RECONNAISSANCE	BEEP* X 4
RECONNAISSANCE	CRUISERS
RECONNAISSANCE	GRISHA CLASS
RECONNAISSANCE	INTELLIGENCE X 2
REPEAT LINE	CARRIAGE RETURN (CTRL M)
REPEAT LINE	D-20
REPEAT LINE	M-240
REPEAT LINE	THREE (3)
RETURN	BEEP* X 4
RETURN	CONFIRMED X 5
RETURN	ELEVEN (11)
RETURN	SEVEN (7) X 2
RETURN	TEN (10) X 2
RIGA CLASS	GRISHA CLASS X 5
RIGA CLASS	VICTOR CLASS X 3
ROMEO CLASS	POLNOCNY CLASS
S-60	SS-16
S-60	SSG X 2
SEVEN	ASSAULT GUNS
SEVEN	BEEP* X 3
SEVEN	ELEVEN
SEVEN	FIVE (5)
SEVEN	SCUD A X 11
SEVEN	SEVENTEEN (17)
SEVEN	SIERA (S) X 2
SEVEN	WHISKEY CLASS
SEVEN	ZSU-57/2
SEVENTEEN	SCUD A X 3
SHERSHEN CLASS	KANIN CLASS X 4
SHIPS	SIX (6) X 2
SIX	BEEP*
SIX	DESTROYERS X 3
SIX	FRIGATES
SIX	INDIA (I)
SIX	SCUD B
SIX	SHIPS X 9
SIX	SPACE ( ) X 20
SIX	T-72
SIXTEEN	BEEP*
SIXTEEN	FIFTEEN (15) X 4
SPACE	AMPHIBIOUS X3
SPACE	BACKSPACE (CTRL A)
SPACE	FRIGATES X 2
SPACE	SHIPS
SPACE	T-12
SS	SSGN
SS	SSM

************* * UTTERANCE * *************	*********************** * MISRECOGNITION(S) * ***********************
SS-14 SCAPEGOAT	SA-8 GECKO X 3
SS-20	SSB
SSB	SSG X 6
SSBN	SSB X 5
SSBN	SSGN X 10
SSG	SSB X 2
SSG	SSGN
SSGN	CHARLIE I CLASS
SSGN	SSBN X 31
SSGN	SSG
SSGN	SSM
SSGN	SSN X 4
SSM	SA-6 GAINFUL
SSM	SSN X 20
SSN	SSM
STENKA CLASS	JULIET CLASS
STENKA CLASS	KANIN CLASS
STENKA CLASS	KYNDA CLASS
STENKA CLASS	NATYA CLASS X 2
STENKA CLASS	SHERSHEN CLASS
STENKA CLASS	VICTOR CLASS X 2
STRIKE/ATTACK	AN-8 CAMP
STRIKE/ATTACK	BEEP* X 2
STRIKE/ATTACK	M-1955
SU-15 FLAGON	IL-38 MAY
SU-19 FENCER	SS-16
SU-A9 FISHPOT	BEEP*
SVERDLOV	BEEP*
SVERDLOV CLASS	OSA I CLASS X 2
SVERDLOV CLASS	POLNOCNY CLASS
SVERDLOV CLASS	STENKA CLASS X 2
SVERDLOV CLASS	YURKA II CLASS
T-34/85	ASU-85
T-34/85	M-1955 X 2
T-34/85	MIG-21 FISHBED
T-34/85	T-54/55
T-34/85	TU-26 BACKFIRE X 3
T-54/55	BEEP* X 2
T-54/55	BMP-76PB
T-54/55	D-44
T-54/55	T-34/85 X 22
T-62	TU-16 BADGER
TANGO	NINE (9)
TANGO CLASS	NATYA CLASS
TANKS	BEEP*
TANKS	BEEP* X 2
TANKS	HEAVY

************* * UTTERANCE * *************	************************ * MISRECOGNITION(S) * ************************
TANKS	NINETEEN (19)
TANKS	TWENTY (20)
TEN	BEEP*
TEN	ELEVEN (11)
THIRTEEN	FIFTEEN (15)
THREE	CARRIER
THREE	FOURTEEN (14) X 2
THREE	FRIGATE X 8
THREE	FROG-3
THREE	HEAVY X 2
THREE	MI-8 HIP
THREE	THIRTEEN (13)
THREE	TWENTY (20)
THREE	TWO (2)
THREE	WHISKEY (W)
TU-22 BLINDER	TU-20 BEAR
TU-28 BEAGLE	IL-14 CRATE X 2
TU-28P FIDDLER	MIG-23 FLOGGER
TWELVE	BEEP*
TWELVE	GOLF
TWENTY	BEEP* X 4
TWENTY	D-30
TWENTY	FOURTEEN (14)
TWENTY	LIGHT
TWENTY	MIKE (M)
TWENTY	NINETEEN (19)
TWENTY	ONE (1)
TWENTY	UPPER RIGHT
TWENTY-FOUR	TWENTY-ONE (21)
TWENTY-ONE	BEEP* X 3
TWENTY-ONE	TWENTY-FOUR (24) X 2
TWENTY-THREE	FROG-3
TWENTY-TWO	BEEP* X 2
LOWER LEFT	LOWER RIGHT X 9
TWENTY-TWO	TWENTY-THREE
TWO	BEEP* X 12
TWO	BTR-152
TWO	EIGHT (8)
TWO	FIFTEEN (15)
TWO	FOUR (4) X 2
TWO	FRIGATE
TWO	HEAVY
TWO	LIGHT
TWO	MEDIUM X 4
TWO	T-10
TWO	T-62
TWO	T-72

************* * UTTERANCE * *************	************************ * MISRECOGNITION(S) * ************************
TWO	TEN (10) X 4
TWO	THREE (3) X 6
TWO	TU-22 BLINDER
TWO	TWENTY-TWO (22) X 5
TWO	YAK-28P FIREBAR
TWO	ZSU-57/2 X 12
TWO	ZU-23/2 X 8
UNIFORM	BRDM
UPPER LEFT	BEEP* X 21
UPPER LEFT	BRAVO CLASS X 3
UPPER LEFT	EIGHTEEN (18)
UPPER LEFT	ELEVEN (11)
UPPER LEFT	KOTLIN CLASS X 3
UPPER LEFT	LOWER LEFT X 5
UPPER LEFT	UPPER RIGHT X 5
UPPER RIGHT	BEEP* X 8
UPPER RIGHT	LIGHT
UPPER RIGHT	LOWER LEFT X 4
UPPER RIGHT	LOWER RIGHT X 9
UPPER RIGHT	UPPER LEFT X 7
VICTOR	BEEP* X 17
VICTOR	CARRIAGE RETURN
VICTOR	CARRIER X 2
VICTOR	D-30
VICTOR	FIFTEEN (15) X 2
VICTOR	FRIGATE X 2
VICTOR	HEAVY
VICTOR	INDIA (I) X 2
VICTOR	M-1955
VICTOR	NOVEMBER (N)
VICTOR	QUEBEC (Q) X 2
VICTOR	SA-8 GECKO
VICTOR	THREE (3) X 2
VICTOR	TU-20 BEAR
VICTOR	WHISKEY
VICTOR CLASS	BEEP*
VICTOR CLASS	KARA CLASS
VICTOR CLASS	KYNDA CLASS X 2
VICTOR CLASS	MIRKA II CLASS
VICTOR CLASS	NANUCHKA CLASS
WHISKEY CLASS	KANIN CLASS
YAK-28P FIREBAR	MIG-19 FARMER
YAK-28P FIREBAR	TU-28P FIDDLER
YANKEE CLASS	KANIN CLASS X 4
YURKA CLASS	KYNDA CLASS
YURKA CLASS	PRIMORYE CLASS
YURKA CLASS	VICTOR CLASS X 3

************* * UTTERANCE * *************	************************ * MISRECOGNITION(S) * ************************
ZERO	BACKSPACE (CTRL A)
ZERO	KILO (K) X 2
ZERO	MOBILE
ZERO	ZSU-57/2 X 2
ZSU-23/4	ZU-23/2 X 2
ZSU-57/2	ASU-57
ZSU-57/2	ZSU-23/4
ZSU-57/2	ZU-23/2
ZU-23/2	SU-19 FENCER
ZU-23/2	TU-22 BLINDER
ZU-23/2	TU-26 BACKFIRE

APPENDIX I

RESULTS FOR PRE/POST SUBJECTIVE QUESTIONNAIRE

The following data reflect whether subjects' attitudes shifted either toward typing or voice as a result of the experiment. A two-tailed sign test was used. Note: Means for the pre/post given below may be misleading if thought to be indicative of the shift. The sign test looks at the fact of whether their was a shift or not, and ignores the amount of shift in the analysis, since the amount may be somewhat arbitrary.

QUESTIONS and PRE / POST MEANS for 20 subjects.	SHIFTS toward TYPING	SHIFTS toward VOICE	NO SHIFT	$\alpha = .10$ Signif?
1. Which data entry mode do you think is the easiest to use to enter character strings and commands? (5.1/6.1)	3	12	5	YES
2. Which data entry mode do you think is the fastest mode for entering character strings and commands? (5.1/5.6)	3	13	4	YES
3. Which data entry mode is the most accurate for entering character strings and commands? (4.1/4.8)	4	9	7	NO
4. Which data entry mode provides the most flexibility, in general, for interaction with a computer? (5.1/5.1)	4	12	4	YES
5. Which data entry mode would you prefer to operate for several hours, if required? (4.3/4.3)	3	8	9	NO

QUESTIONS and PRE / POST MEANS for 20 subjects.	SHIFTS toward TYPING	SHIFTS toward VOICE	NO SHIFT	$\alpha = .10$ Signif?
6. Which data entry mode would you prefer to operate as a more sporadic user of a computer system? (4.3/4.3)	3	10	7	YES
7. Which data entry mode promotes the most relaxed operation? (5.0,5.1)	5	8	7	NO
8. Which data entry mode would be the most advantageous to use to update an on-line data base of intelligence information? (5.1/5.0)	3	9	8	NO
9. Which data entry mode provides the best man-machine interface in a time-critical, high pressure work environment? (5.0/5.0)	5	12	3	NO
10. Which data entry mode do you think is the easiest to to learn? (4.9/5.6)	2	13	5	YES

LIST OF REFERENCES

1. Lea, W. A., Trends in Speech Recognition, Prentice-Hall Inc., p. 88-89, 1980.

2. Naval Postgraduate School Report NPS-55-80-016, Experiments with Voice Input for Command and Control, by G.K.Poock, April 1980.

3. Lawson, J. S., "Naval Tactical C3 Architecture 1985-1995," Signal, p. 72-76, August 1976.

4. Lea, op. cit., p. 3.

5. Rome Air Development Center Briefing, "DOD Automated Exploitation System," February 1981.

6. Ibid.

7. Lea, op. cit., p. 30-33.

8. Lea, op. cit., p. 40.

9. Lea, op. cit., p. 24.

10. Lea, op. cit., p. 92.

11. Lea, op. cit., p. 4-7.

12. Beek, B., Neuberg, E.P. and Hodge, D.C., "An Assessment of the Technology of Automatic Speech Recognition for Military Applications," IEEE Transactions Acoustics, Speech, and Signal Processing, ASSP-25, Number 4, p. 310-322, 1977.

13. Rome Air Development Center Report RADC-TR-80-220, DIMS Voice Data Entry, by Phillips B. Scott, Threshold Technology Inc., June 1980.

14. Rome Air Development Center Report RADC-TR-78-209, Word Recognition, by Phillips B. Scott, Threshold Technology Inc., September 1978.

15. Rome Air Development Center Report RADC-TR-77-184, Alpha/Numeric Extraction Technique Phase II, by Phillips B. Scott, Threshold Technology Inc., May 1977.

16. Poock, op. loc.

17. McSorley, W., Using Voice Recognition to Run the Warfare Environment Simulator (WES), Masters Thesis, Naval Postgraduate School, Monterey, California, March 1981.

18. Rome Air Development Center Report RADC-TR-80-74, Advanced Image Exploitation Aids, by John R. Welch and E. Shamsi, March 1980.

19. Poock, op. loc.

20. Threshold 600 User's Manual, Threshold Technology Inc., 1978.

21. Conners, E., and Vance C., "Operation of the G-1130 Harvard Tachistoscope and Peripheral Equipment," Naval Postgraduate School CS 3665 Paper, p. 1-3, September 1978.

22. United States Strategic Institute Report, USSI 76-2, Soviet Warsaw Pact Force Levels, by J. Erickson, 1976.

23. Donnely, C., and others, The Soviet War Machine: An Encyclopedia of Russian Military Equipment and Strategy, Chartwell Books, Inc. 1978.

24. Defense Intelligence Agency DBB-2680-40-78, Handbook on the Soviet Armed Forces, February 1978.

25. Wiener, F., The Armies of the Warsaw Pact Nations, 2nd ed., Carl Ueberreuter Publishers, 1978.

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Wright-Patterson AFB, Ohio 45433

136. California Institute of Technology 1
Jet Propulsion Laboratory
Systems Analysis Section
ATTN: Robert L. Sohn
4800 Oak Grove Drive
Pasadena, California 91103

137. Massachusetts Institute of Technology 1
Lincoln Laboratories
ATTN: Cliff Weinstein
Room B-335
Lexington, Massachusetts 02173

138. David Joly 1
2180 Bryant Street
San Francisco, California 94110

139. Naval Training Equipment Center 1
Human Factors Laboratory
ATTN: Elizabeth Lambert, Code N-711
Orlando, Florida 32813

140. Threshold Technology, Incorporated 1
ATTN: Fred Gladney
Suite 4 - C1
1440 South State College Blvd.
Anaheim, California 92806

141. Heuristics, Inc. 1
ATTN: Tom Imperato
1285 Hammerwood Avenue
Sunnyvale, California 94086

142. XYBION 1
ATTN: Paul Frost
7 Ridgedale Avenue
Cedar Knolls, New Jersey 07927

143. Threshold Technology, Incorporated 1
ATTN: John Welch
1829 Underwood Blvd.
Delran, New Jersey 08075

144. Office of Naval Research 1
ATTN: Robert Wisher, Code 458
800 North Quincy Street
Arlington, Virginia 22217

145. Honeywell, Incorporated 1
Systems and Research Center
ATTN: Robert North
2600 Ridgeway Blvd.
Minneapolis, Minnesota 55413

146. National Bureau of Standards 1
Information-Communications Systems Technology
ATTN: Dave Pallett
A219 Technology Building
Washington, D.C. 20234

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Jay

An experiment in
voice data entry for
imagery interpretation
reporting.